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Volume XXXV - Fascicolo I

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ANTONIO DE ANGELI & ALESSANDRO GARASSINO

CATALOG AND BIBLIOGRAPHY OF THE FOSSIL STOMATOPODA AND DECAPODA FROM ITALY

MILANO NOVEMBRE 2006

Elenco delle Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano

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Antonio De Angeli & Alessandro Garassino

Associazione Amici del Museo Zannato di Montecchio Maggiore
Museo Civico di Storia Naturale di Milano

Catalog and bibliography of the fossil Stomatopoda and Decapoda from Italy

Volume XXXV - Fascicolo I

Novembre 2006

Memorie della Società Italiana di Scienze Naturali
e del Museo Civico di Storia Naturale di Milano

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Museo Civico di Storia Naturale di Milano
Corso Venezia , 55 - 20121 Milano

In copertina: from left to right, *Titanocarcinus aculeatus* Busulini, Tessier & Visentin, 1984 (Reconstruction A. De Angeli), *Rosenfeldia triasica* Garassino, Teruzzi & Dalla Vecchia, 1996 (Reconstruction F. Fogliazza).

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Catalog and bibliography of the fossil Stomatopoda and Decapoda from Italy

INTRODUCTION

The rich Italian decapod faunas, reported from the Triassic to Pleistocene, have been the subject of many studies by Italian and foreign researchers for over two centuries. Important studies were carried out by famous palaeontologists, such as Ristori, Crema, A. Sismonda, E. Sismonda, Bittner, A. Milne Edwards, Reuss, and Lovisato, who pioneered the systematic study of Italian decapod crustaceans between the middle of the nineteenth century and the beginning of the last century. Unfortunately, not many studies were carried out in the first half of the twentieth century following this initial effort. In the last thirty years, the discovery of rich decapod faunas in many outcrops reported in Piemonte, Lombardia, Veneto, Friuli-Venezia Giulia, and Campania has given a new impulse to the carcinological studies. The numerous systematic papers, published in these last years by Italian researchers and collaborators of the Museo Civico di Storia Naturale di Milano and of the Museo Civico "G. Zannato" di Montecchio Maggiore (Vicenza), have resulted in an increase in the knowledge of Mesozoic and Cenozoic decapod crustaceans of Italy by the descriptions of new genera and species of stomatopods, anomurans, macrurans and brachyurans.

The main purposes of this catalog are essentially three:

1 – To locate the Italian Museum or University in which the nineteenth century collections are housed in order to give an updated check list of the holotypes.

2 – To give an updated check list of the carcinological studies under way today in Italy.

3 – To provide a valid work instrument for the reasearchers to supplement "Treatise on Invertebrate Paleontology", published by Glaessner (1969).

Finally, we note that the research of the original specimens from Sardegna, studied by Meneghini, Lörenthey, Lovisato, Comaschi Caria, and Marras & Ventura; from Puglia, studied by Varola, Bonfiglio & Donadeo, and Ristori; and from Piemonte, studied by Allasinaz was very difficult because of the catalogue numbers and, in some cases, the entire collections are missing. Moreover, we note that many specimens housed in Museo dei Fossili di Bolca (Verona) and Museo Civico "G. Zannato" di Montecchio Maggiore (Vicenza) are reported with the acronym I.G. (Inventario Generale dello Stato).

The systematic arrangement used in this catalog follows the classification proposed by Martin & Davis (2001).

ABBREVIATIONS FOR INSTITUTIONS HOLDING SPECIMENS

A	Collezione Prof. P. De Castro, Napoli
BSPG	Bayerische Staatssammlung für Paläontologie und Geologie, Munich (Germany)
DIP.TE.RIS.	Dipartimento per lo Studio del Territorio e delle sue Risorse, Genova
DGUN	Dipartimento di Geologia dell'Università di Napoli
GNSL	Gruppo Naturalisti Salentini, Lecce
I.G.	Inventario Generale dello Stato
IGF	Museo Geologico e Paleontologico, Firenze
M	Museo di Paleontologia, Napoli
MAFI	Magyar Allami Földtani Intézet, Budapest (Hungary)
MCC	Museo Civico "Craveri", Bra (Cuneo)
MCSM	Museo del Collegio Serafico Missionario, Chiampo (Vicenza)
MCSN	Museo Civico di Scienze Naturali, Ovada (Alessandria)
MCV	Museo Civico, Vignola (Modena)
MCZ	Museo Civico "G. Zannato", Montecchio Maggiore (Vicenza)
MFB	Museo dei Fossili, Bolca (Verona)
MFS	Museo dei Fisiocratici, Siena
MFSN	Museo Friulano di Storia Naturale, Udine
MG	Museo Geologico, Castell'Arquato (Piacenza)
MGPD	Museo del Dipartimento di Geologia, Paleontologia e Geofisica dell'Università di Padova
MGPUP	Museo Geologico e Paleontologico dell'Università di Parma
MGPUR	Museo Geologico e Paleontologico dell'Università di Roma
MGSB	Museo Geológico del Seminario de Barcelona, Barcelona (Spain)
MGUM	Museo Geologico dell'Università di Modena
MGUP	Museo di Geologia e Paleontologia "G. G. Gemmellaro", Palermo

MGV	Museo Gasola, Verona
MHMW	Naturhistorisches Museum, Wien (Austria)
MMGB	Museo Municipal de Geologia de Barcelona, Barcelona (Spain)
MNAV	Museo Naturalistico Archeologico, Vicenza
MNCNM	Museo Nacional de Ciencias Naturales, Madrid (Spain)
MNHB	Museum für Naturkunde der Humboldt-Universität, Berlin (Germany)
MNHN	Muséum national d'Histoire naturelle, Paris (France)
MPM	Museo Paleontologico di Maglie, Lecce
MPP	Museo Palazzo Poggi, Bologna
MPUP	Museo di Paleontologia dell'Università di Pisa
MS	Muséum de la Sorbonne, Paris (France)
MSNB	Museo di Scienze Naturali "E. Caffi", Bergamo
MSNBS	Museo di Scienze Naturali, Brescia
MSNM	Museo Civico di Storia Naturale, Milano
MSNTC	Museo di Scienze Naturali e del Territorio di Calci, Pisa
MSNV	Museo di Storia Naturale, Verona
MSNVE	Museo di Storia Naturale, Venezia
MV	Museo Civico "D. Dal Lago", Valdagno (Vicenza)
NHM	Natural History Museum, London (Great Britain)
PU	Museo Regionale di Scienze Naturali, Torino
SGR	Servizio Geologico di Roma
SV, (*)	Collezione Soci della Società Veneziana, Venezia

SYSTEMATIC CATALOG

Order Stomatopoda Latreille, 1817
Superfamily Gonodactyloidea Giesbrecht, 1910
Family Pseudosquillidae Manning, 1977

Pseudosquilla Dana, 1852

Type species: *Squilla ciliata* Fabricius, 1787.
Stratigraphic range: Eocene – Recent.

Pseudosquilla berica De Angeli & Messina, 1996

1996 – *Pseudosquilla berica* De Angeli & Messina; p. 6, Text-fig. 2, Pl. 1 (fig. 1 a-c)
2000 – *Pseudosquilla berica* De Angeli & Messina *in* Hof; p. 35
2001 – *Pseudosquilla berica* De Angeli & Messina *in* De Angeli & Beschin; p. 40, Text-fig. 35
2004 – *Pseudosquilla berica* De Angeli & Messina *in* Schram & Müller; p. 76
2006 – *Pseudosquilla berica* De Angeli & Messina *in* De Angeli & Rossi; p. 86, Pl. 2 (fig. 5)

Holotype: MCZ 1547 (I.G. 284625).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli & Messina (1996) reported one specimen (MCZ 1547) from Perarolo (Vicenza).

Superfamily Lysiosquilloidea Giesbrecht, 1910
Family Lysiosquillidae Giesbrecht, 1910

Lysiosquilla Dana, 1852

Type species: *Squilla scabricauda* Lamarck, 1818.
Stratigraphic range: Cretaceous – Recent.

Lysiosquilla antiqua (Münster, 1842)

1842 – *Squilla antiqua* Münster; p. 76, Pl. 9 (fig. 11)
1915 – *Squilla antiqua* Münster *in* Fabiani; p. 284
1975 – *Lysiosquilla antiqua* (Münster) *in* Secretan; p. 371, Text-figs. 23-32, Pls. 26-33
1975 – *Lysiosquilla antiqua* var. *minor* Secretan; p. 378, Text-fig. 33, Pls. 34-37, **nov syn.**
1996 – *Lysiosquilla antiqua* (Münster) *in* De Angeli & Messina; p. 9
2004 – *Lysiosquilla antiqua* (Münster) *in* Schram & Müller; p. 90

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Münster (1842) reported one specimen from Monte Bolca (Verona) (repository and catalogue number unknown); Secretan (1975) reported 35 specimens from the same quarry (MSNV x, 03, 50, 50bis, 51, 51bis, 52, 53, 54, 56, 58, 57, from 59 to 68, from 70 to 84, 86, 88, 89, Z1, Z2, B7, B8, B55, B55bis, F1, F3, F4, F6, Cr4, Cr5; MGPD 10923, 12546, 12549).
Note: Schram & Müller (2004) considered *L. antiqua* var. *minor* Secretan, 1975, as synonym with *L. antiqua* (Münster, 1842).

Lysiosquilla messinai De Angeli, 1997

1997 – *Lysiosquilla messinae* De Angeli; p. 24, Tex-fig. 1
2001 – *Lysiosquilla messinae* De Angeli *in* De Angeli & Beschin; p. 40
2004 – *Lysiosquilla messinae* De Angeli *in* Schram & Müller; p. 91
2006 – *Lysiosquilla messinai* De Angeli *in* De Angeli & Rossi; p. 86, Pl. 2 (fig. 2)

Holotype: MCZ 1546 (I.G. 284624).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli (1997) reported one specimen (MCZ 1546) from Perarolo (Vicenza).

Superfamily Squilloidea Latreille, 1802
Family Squillidae Latreille, 1802

Squilla Fabricius, 1787

Type species: *Cancer mantis* Linnaeus, 1758.
Stratigraphic range: (?Cretaceous) Eocene – Recent.

Squilla miocenica Lovisato, 1894

1894 – *Squilla miocenica* Lovisato; p. 207, Text-figs. 1-3
1949 – *Squilla miocenica* Lovisato *in* Via Boada; p. 2, Text-fig. 1
1956 – *Squilla miocenica* Lovisato *in* Comaschi Caria; p. 288
1996 – *Squilla miocenica* Lovisato *in* De Angeli & Messina; p. 9
1998 – *Squilla miocenica* Lovisato *in* Hof; p. 1570
2004 – *Squilla miocenica* Lovisato *in* Schram & Müller; p. 199

Holotype: unknown.
Stratigraphic range: middle Miocene (Badenian).
Occurrence: Sardegna.
Material: Lovisato (1894) reported three specimens from Cagliari (repository and catalogue number unknown).
Note: this species is also reported from the upper Miocene (Tortonian) of Montjuich (Spain).

Indeterminates
Genere e specie indeterminati

2005 – Genere e specie indeterminati *in* Beschin, De Angeli, Checchi & Zarantonello; p. 26, Text-fig. 18, Pl. 4 (fig. 7)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported one specimen (MCZ 1554) from Grola di Cornedo Vicentino (Vicenza).

Order Decapoda Latreille, 1802
Suborder Dendrobranchiata Bate, 1888
Superfamily Penaeoidea Rafinesque-Schmaltz, 1815
†Family Aegeridae Burkenroad, 1963

Aeger Münster, 1839

Type species: *Macrourites tipularius* Schlotheim, 1822.
Stratigraphic range: Upper Triassic (Carnian) – Upper Cretaceous (Cenomanian).

Aeger elongatus Garassino & Teruzzi, 1990

1990 – *Aeger elongatus* Garassino & Teruzzi; p. 118, Text-fig. 24

Holotype: MSNM i8772.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1990) reported two specimens (MSNM i8771, i8772) from Osteno (Como).

Aeger foersteri Garassino & Teruzzi, 1990

1990 – *Aeger foersteri* Garassino & Teruzzi; p. 106, Text-figs. 1, 10-12

Holotype: MSNM i8749.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1990) reported seven specimens (MSNM from i8742 to i8746, i8748, i8749) from Osteno (Como).

Aeger macropus Garassino & Teruzzi, 1990

1990 – *Aeger macropus* Garassino & Teruzzi; p. 117, Text-fig. 23

Holotype: MSNM i8770.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1990) reported one specimen (MSNM i8770) from Osteno (Como).

Aeger muensteri Garassino & Teruzzi, 1990

1990 – *Aeger muensteri* Garassino & Teruzzi; p. 109, Text-figs 2-3, 13-14

Holotype: MSNM i8752.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1990) reported three specimens (MSNM i8750, i8751, i8752) from Osteno (Como).

Aeger robustus Garassino & Teruzzi, 1990

1990 – *Aeger robustus* Garassino & Teruzzi; p. 112, Text-figs. 4, 15-16, 18-21

Holotype: MSNM i8759.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1990) reported ten specimens (MSNM from i8753 to i8762) from Osteno (Como).

Aeger rostrospinatus Garassino & Teruzzi, 1990

1990 – *Aeger rostrospinatus* Garassino & Teruzzi; p. 114, Text-figs. 5-8, 22

Holotype: MSNM i8768.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1990) reported six specimens (MSNM from i8763 to i8769) from Osteno (Como).

Aeger sp.

1974 – *Aeger* sp. *in* Pinna; p. 21, Pl. 1 (fig. 4)

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Pinna (1974) reported one specimen (MSNB 3160) from Cene (Bergamo).

Family Penaeidae Rafinesque-Schmaltz, 1815

Antrimpos Münster, 1839

Type species: *Antrimpos speciosus* Münster, 1839.
Stratigraphic range: Upper Triassic (Carnian) – Upper Jurassic (Portlandian).

Antrimpos noricus Pinna, 1974

1974 – *Antrimpos noricus* Pinna; p. 14, Text-figs. 4-8, Pls. 2-11
1976 – *Antrimpos noricus* Pinna *in* Pinna; p. 34, Pl. 1 (figs. 1-2), Pl. 3 (fig. 2)

1990 – *Autrimpos* sp. *in* Dalla Vecchia; p. 137, Text-fig. 37
1991 – *Antrimpos* sp. *in* Dalla Vecchia; p. 26
1996 – *Antrimpos noricus* Pinna *in* Garassino, Teruzzi & Dalla Vecchia; p. 30

Holotype: MSNB 3380.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia, Friuli Venezia-Giulia.
Material: Pinna (1974) reported 149 specimens (the best specimens are: MSNB 3110, 3111, 3122, 3130, 3133, 3134, 3136, 3137, 3380; MSNM i4480, i4485) from Cene (Bergamo); Pinna (1976) reported 34 specimens (the best specimens are: MSNBS 2771, 2773, 2780, 2932, 2978) from Rest (Brescia); Garassino *et al.* (1996) reported 11 specimens (MFSN 1421, 1536 b-c, 1655, 16096, 16101, 16109, 16142 a-b, 16166, 1722 a-b, 1731, 13720) from Rio Seazza (Udine).

Antrimpos sp.

2001 – *Antrimpos* sp. *in* Garassino & Teruzzi; p. 189, Text-fig. 1

Stratigraphic range: Lower Jurassic (Toarcian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (2001) reported one specimen (MSNM i10852) from Sogno (Bergamo).

Dusa Münster, 1839

Type species: *Dusa monocera* Münster, 1839.
Stratigraphic range: Upper Triassic (Norian) – Upper Jurassic (Portlandian).

Dusa longipes (Pinna, 1974)

1974 – *Palaeodusa longipes* Pinna; p. 21, Text-figs. 9-10, Pl. 1 (fig. 5), Pl. 12 (fig. 1), Pl. 13 (figs. 1-3)
1976 – *Palaeodusa longipes* Pinna *in* Pinna; p. 36, Text-fig. 1, Pl. 2 (figs. 1-2)
1990 – *Dusa denticulata* Münster *in* Dalla Vecchia; p. 122, Text-fig. 21, Pls. 31-35
1991 – *Dusa denticulata* Münster *in* Dalla Vecchia; p. 22, Text-figs. 15-17
1996 – *Dusa longipes* (Pinna) *in* Garassino, Teruzzi & Dalla Vecchia; p. 24, Text-figs. 2-5, 11-15

Holotype: MSNB 3422.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia, Friuli-Venezia Giulia, Lazio.
Material: Pinna (1974) reported 43 specimens from Cene (Bergamo), (MSNB, catalogue number unknown); Pinna (1976) reported three specimens (MSNBS 2930, 2937, 3012) from Rest (Brescia); Garassino *et al.* (1996) reported 58 specimens (MFSN 992, 1416, 1417, 1418, 1420, 1427, 1431, 1433, 1434, 1439, 1442, 1446, 1449, 1469, 1474, 1475, 1491, 1493, 1494, 1509, 1554, 1588, 1590, 1592, 1604, 1680, 1688, 1697, 1698, 1703, 1715, 1730, 1893, 1895, 1951, 6441, 13717, 13722, 13725, 13804, 13808, 13809, 15381, 16094, 16097, 16098, 16099, 16100, 16103, 16105, 16106, 16107, 16167, 16168, 16169, 16385, 18455) from Rio Seazza, Rio Forchiar, Forni di Sopra, Rio di Donna, and Rio Secco (Udine).

Note: Dalla Vecchia (1991) reported some specimens (the best specimens are: MFSN 1607, 6441) ascribing them to *Dusa denticulata* Münster, 1839. Probably these specimens could be ascribed to *Dusa longipes*.

Dusa cfr. *D. longipes* (Pinna, 1974)

1993 – *Palaeodusa* cfr. *P. longipes* Pinna *in* Garassino & Teruzzi; p. 11, Text-fig. 16

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported two specimens (MSNB 7737, 8314) from Ponte Giurino (Bergamo).

Dusa sp.

1993 – *Dusa* sp. *in* Dalla Vecchia; p. 62, Text-figs. 3-4

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lazio.
Material: Dalla Vecchia (1993) reported 11 specimens (MFSN from 15100 to 15111) from Filettino (Lazio).

Longichela Garassino & Teruzzi, 1993

Type species: *Longichela orobica* Garassino & Teruzzi, 1993.
Stratigraphic range: Upper Triassic (Norian).

Longichela orobica Garassino & Teruzzi, 1993

1993 – *Longichela orobica* Garassino & Teruzzi; p. 5, Text-figs. 3-8, Pl. 1 (figs. 1-2)

Holotype: MSNM i10738.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported 154 specimens (the best specimens are: MSNM i10739, i10744, i10751, i10752; MSNB 7725, 7748, 7751, 7760) from Ponte Giurino (Bergamo).

Longichela cfr. *L. orobica* Garassino & Teruzzi, 1993

1993 – *Longichela* cfr. *L. orobica in* Garassino & Teruzzi; p. 8, Text-figs. 9-11, Pl. 1 (fig. 3)

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported two specimens (MSNB 8198, 8199-8200) from Ponte Giurino (Bergamo).

Micropenaeus Bravi & Garassino, 1998

Type species: *Micropenaeus tenuirostris* Bravi & Garassino, 1998.
Stratigraphic range: Lower Cretaceous (Albian).

Micropenaeus tenuirostris Bravi & Garassino, 1998

1998a – *Micropenaeus tenuirostris* Bravi & Garassino; p. 152, Text-fig. 23

Holotype: M 21833.
Stratigraphic range: Lower Cretaceous (Albian).
Occurrence: Campania.
Material: Bravi & Garassino (1998a) reported one specimen (M 21833) from Pietraroia (Benevento).

Penaeus Fabricius, 1798

Type species: by subsequent designation of Latreille, 1810, *Penaeus monodon* Fabricius, 1798.
Stratigraphic range: Lower Cretaceous (Hauterivian–Barremian) – Recent.

Penaeus bolcensis Secretan, 1975

1975 – *Penaeus bolcensis* Secretan; p. 327, Text-figs. 4-6, Pls. 2-4
1996 – *Penaeus bolcensis* Secretan *in* Garassino & Teruzzi; p. 4
1999 – *Penaeus bolcensis* Secretan *in* Beschin & Garassino; p. 194

Holotype: MSNV 100.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported one specimen (MSNV 100) from Monte Bolca (Verona).

Penaeus cornappensis Garassino, 1998

1998 – *Penaeus cornappensis* Garassino; p. 60, Text-fig. 1

Holotype: MFSN 21536.
Stratigraphic range: Lower Cretaceous (Barremian – Aptian).
Occurrence: Friuli-Venezia Giulia.
Material: Garassino (1998) reported four specimens (MFSN 21535, 21536, 21542, 21543) from Torrente Cornappo (Udine).

Penaeus obtusus Secretan, 1975

1975 – *Penaeus obtusus* Secretan; p. 330, Text-figs. 7-9, Pls. 7-10
1996 – *Penaeus obtusus* Secretan *in* Garassino & Teruzzi; p. 4
1999 – *Penaeus obtusus* Secretan *in* Beschin & Garassino; p. 194

Holotype: MSNV 106.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported one specimen (MSNV 106) from Monte Bolca (Verona).

Penaeus sorbinii Beschin & Garassino, 1999

1999 – *Penaeus sorbinii* Beschin & Garassino; p. 201, Text-figs. 8-10
2001 – *Penaeus sorbinii* Beschin & Garassino *in* De Angeli & Beschin; p. 10

Holotype: MSNM i24505.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin & Garassino (1999) reported three specimens (MSNM i12633, i24505; MCZ 1583) from Salcedo (Vicenza).

Penaeus vanzii Beschin & Garassino, 1999

1999 – *Penaeus vanzii* Beschin & Garassino; p. 197, Text-figs. 4-7
2001 – *Penaeus vanzii* Beschin & Garassino *in* De Angeli & Beschin; p. 10, Text-fig. 4

Holotype: MSNM i24501.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin & Garassino (1999) reported 26 specimens (MSNM i8408, i9164, i9165-i9166, i9167-i9169, from i9173 to i9176, i12634, i13593, from i24501 to i24504; MCZ from 1580 to 1582 and from 1604 to 1612) from Valle del Ponte (Vicenza).

Penaeus vernassensis Garassino & Teruzzi, 1995

1995 – *Penaeus vernassensis* Garassino & Teruzzi; p. 80, Text-fig. 2

Holotype: MFSN 17052.
Stratigraphic range: Lower Cretaceous (Hauterivian–Barremian).
Occurrence: Friuli-Venezia Giulia.
Material: Garassino & Teruzzi (1995) reported three specimens (MFSN 4308 a-b, 4310, 17052) from Vernasso (Udine).

Pseudobombur Secretan, 1975

Type species: *Pseudobombur nummuliticus* Secretan, 1975.
Stratigraphic range: middle Eocene (Lutetian).

Pseudobombur nummuliticus Secretan, 1975

1975 – *Pseudobombur nummuliticus* Secretan; p. 332, Text-fig. 10, Pl. 11 (figs. 1-3), Pl. 12 (fig. 2)
1996 – *Pseudobombur nummuliticus* Secretan *in* Garassino & Teruzzi; p. 4
1999 – *Pseudobombur nummuliticus* Secretan *in* Beschin & Garassino; p. 194

Holotype: MSNV 103.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported six specimens (MSNV 102 bis, 103, 104, 106, 111 bis, 122) from Monte Bolca (Verona).

Satyrocaris Garassino & Teruzzi, 1994

Type species: *Satyrus cristatus* Garassino & Teruzzi, 1993.
Stratigraphic range: Upper Triassic (Norian).

Satyrocaris cristatus (Garassino & Teruzzi, 1993)

1993 – *Satyrus cristatus* Garassino & Teruzzi; p. 9, Text-figs. 12-14, Pl. 1 (fig. 4), Pl. 2 (figs. 1-2)
1994 – *Satyrocaris cristatus* (Garassino & Teruzzi) *in* Garassino & Teruzzi; p. 293

Holotype: MSNB 8190.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.

Material: Garassino & Teruzzi (1993) reported nine specimens (MSNB 7790, 8190, 8240, 8248, 8299, 8338, 8341, 8350) from Ponte Giurino (Bergamo).

Indeterminates
Indeterminate penaeid

1993 – Indeterminate penaeid *in* Garassino & Teruzzi; p. 11, Text-fig. 15, Pl. 2 (fig. 3)

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported one specimen (MSNB 7779) from Ponte Giurino (Bergamo).

Penaeid, genus and species indeterminate

1993 – Penaeid, genus and species indeterminate *in* Garassino & Teruzzi; p. 12, Text-fig. 17

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported five specimens (MSNB 7718, 7723, 7762, 7778; MSNM i10753) from Ponte Giurino (Bergamo).

Infraorder Caridea Dana, 1852
Family Oplophoridae Dana, 1852

Tonellocaris Garassino, 1998

Type species: *Tonellocaris brevirostrata* Garassino, 1998.
Stratigraphic range: Lower Cretaceous (Barremian – Aptian).

Tonellocaris brevirostrata Garassino, 1998

1998 – *Tonellocaris brevirostrata* Garassino; p. 64, Text-figs. 2-3
1999 – *Tonellocaris brevirostrata* Garassino *in* Bravi, Coppa, Garassino & Patricelli; p. 162
2001 – *Tonellocaris brevirostrata* Garassino *in* Garassino & Teruzzi; p. 151
2002 – *Tonellocaris brevirostrata* Garassino *in* Garassino, Schram, Taylor & Shen; p. 78
2003 – *Tonellocaris brevirostrata* Garassino *in* Garassino & Bravi; p. 590
2005 – *Tonellocaris brevirostrata* Garassino *in* Garassino & Jakobsen; p. 102

Holotype: MFSN 21537.
Stratigraphic range: Lower Cretaceous (Barremian – Aptian).
Occurrence: Friuli-Venezia Giulia.
Material: Garassino (1998) reported three specimens (MFSN 21537, 21540, 21541) from Torrente Cornappo (Udine).

Family Palaemonidae Rafinesque-Schmaltz, 1815

Alburnia Bravi & Garassino, 1998

Type species: *Alburnia petinensis* Bravi & Garassino, 1998.
Stratigraphic range: Lower Cretaceous (Albian).

Alburnia petinensis Bravi & Garassino, 1998

1998b – *Alburnia petinensis* Bravi & Garassino; p. 107, Text-figs. 11-13
1998a – *Alburnia petinensis* Bravi & Garassino *in* Bravi & Garassino; p. 155
1998 – *Alburnia petinensis* Bravi & Garassino *in* Garassino; p. 67
1999 – *Alburnia petinensis* Bravi & Garassino *in* Bravi, Coppa, Garassino & Patricelli; p. 162
2001 – *Alburnia petinensis* Bravi & Garassino *in* Garassino & Teruzzi; p. 151
2002 – *Alburnia petinensis* Bravi & Garassino *in* Garassino, Schram, Taylor & Shen; p. 78
2003 – *Alburnia petinensis* Bravi & Garassino *in* Garassino & Bravi; p. 590
2005 – *Alburnia petinensis* Bravi & Garassino *in* Garassino & Jakobsen; p. 102

Holotype: M 21834.
Stratigraphic range: Lower Cretaceous (Albian).
Occurrence: Campania.
Material: Bravi & Garassino (1998b) reported three specimens (M 21834, 21835, 21836) from Petina (Salerno).

Palaemon Weber, 1795

Type species: *Palaemon adspersus* Rathke, 1837.
Stratigraphic range: Lower Cretaceous (Aptian) – Recent.

Palaemon antonellae Garassino & Bravi, 2003

2003 – *Palaemon antonellae* Garassino & Bravi; p. 589, Text-figs. 1-2
2005 – *Palaemon antonellae* Garassino & Bravi *in* Garassino & Jakobsen; p. 103

Holotype: PrC24.
Stratigraphic range: Lower Cretaceous (Aptian).
Occurrence: Campania.
Material: Garassino & Bravi (2003) reported 53 specimens (the best specimens are: DGUN PrC1, PrC2, PrC7, PrC13, PrC24) from Profeti (Caserta).

Palaemon fabricii Michelotti, 1861

1861 – *Palaemon fabricii* Michelotti; p. 141, Pl. 14 (fig. 4)
1929 – *Palaemon fabricii* Michelotti *in* Glaessner; p. 291

Holotype: unknown.
Stratigraphic range: upper Oligocene (Chattian).
Occurrence: Veneto.
Material: Michelotti (1861) reported one specimen from Salcedo (Vicenza) (repository and catalogue number unknown).

Palaemon vesolensis Bravi, Coppa, Garassino & Patricelli, 1999

1999 – *Palaemon vesolensis* Bravi, Coppa, Garassino & Patricelli; p. 159, Text-figs. 13-17

2001 – *Palaemon vesolensis* Bravi, Coppa, Garassino & Patricelli *in* Garassino & Teruzzi; p. 151
2002 – *Palaemon vesolensis* Bravi, Coppa, Garassino & Patricelli *in* Garassino, Schram, Taylor & Shen; p. 78
2003 – *Palaemon vesolensis* Bravi, Coppa, Garassino & Patricelli *in* Garassino & Bravi; p. 590
2005 – *Palaemon vesolensis* Bravi, Coppa, Garassino & Patricelli *in* Garassino & Jakobsen; p. 103

Holotype: A 4491/8.
Stratigraphic range: Upper Cretaceous (Campanian-Maastrichtian).
Occurrence: Campania.
Material: Bravi *et al.* (1999) reported 93 specimens (A 4491/from 1 to 31, 34, 41; MSNM from i24731 to i24796) from Monte Vesole (Salerno).

Palaemon sp.

1892c – *Palaemon* sp. *in* Ristori; p. 160
1910a – *Palaemon* sp. *in* Fabiani; p. 18

Stratigraphic range: upper Oligocene (Rupelian).
Occurrence: Veneto.
Material: Ristori (1892c) and Fabiani (1910a) reported some specimens from Chiavon (Vicenza) (repository and catalogue number unknown).

Indeterminate family

Acanthinopus Pinna, 1974

Type species: *Acanthinopus gibbosus* Pinna, 1974.
Stratigraphic range: Upper Triassic (Norian).

Acanthinopus gibbosus Pinna, 1974

1974 – *Acanthinopus gibbosus* Pinna; p. 23, Pl. 12 (fig. 3), Pl. 13 (fig. 5)
1996 – *Acanthinopus gibbosus* Pinna *in* Garassino, Teruzzi & Dalla Vecchia; p. 32
1996 – *Acanthinopus gibbosus* Pinna *in* Garassino & Teruzzi; p. 8
1997 – *Acanthinopus gibbosus* Pinna *in* Garassino; p. 107
1998a – *Acanthinopus gibbosus* Pinna *in* Bravi & Garassino; p. 155
1998b – *Acanthinopus gibbosus* Pinna *in* Bravi & Garassino; p. 108
1998 – *Acanthinopus gibbosus* Pinna *in* Garassino; p. 65
1999 – *Acanthinopus gibbosus* Pinna *in* Bravi, Coppa, Garassino & Patricelli; p. 161
2001 – *Acanthinopus gibbosus* Pinna *in* Garassino & Teruzzi; p. 150
2002 – *Acanthinopus gibbosus* Pinna *in* Garassino, Schram, Taylor & Shen; p. 76
2003 – *Acanthinopus gibbosus* Pinna *in* Garassino & Bravi; p. 590
2005 – *Acanthinopus gibbosus* Pinna *in* Garassino & Jakobsen; p. 102

Holotype: MSNB 3109.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia, Friuli-Venezia Giulia.
Material: Pinna (1974) reported one specimen (MSNB 3109) from Cene (Bergamo); Garassino *et al.* (1996) reported two specimens (MFSN 16104 a-b, 18454 a-b) from Rio Seazza (Udine).

Leiothorax Pinna, 1974

Type species: *Leiothorax triasicus* Pinna, 1974.
Stratigraphic range: Upper Triassic (Norian).

Leiothorax triasicus Pinna, 1974

1974 – *Leiothorax triasicus* Pinna; p. 24, Pl. 12 (fig. 2), Pl. 13 (fig. 4)
1996 – *Leiothorax triasicus* Pinna *in* Garassino, Teruzzi & Dalla Vecchia; p. 33
1996 – *Leiothorax triasicus* Pinna *in* Garassino & Teruzzi; p. 8
1997 – *Leiothorax triasicus* Pinna *in* Garassino; p. 107
1998a – *Leiothorax triasicus* Pinna *in* Bravi & Garassino; p. 155
1998b – *Leiothorax triasicus* Pinna *in* Bravi & Garassino; p. 108
1998 – *Leiothorax triasicus* Pinna *in* Garassino; p. 65
1999 – *Leiothorax triasicus* Pinna *in* Bravi, Coppa, Garassino & Patricelli; p. 161
2001 – *Leiothorax triasicus* Pinna *in* Garassino & Teruzzi; p. 150
2002 – *Leiothorax triasicus* Pinna *in* Garassino, Schram, Taylor & Shen; p. 76
2003 – *Leiothorax triasicus* Pinna *in* Garassino & Bravi; p. 590
2005 – *Leiothorax triasicus* Pinna *in* Garassino & Jakobsen; p. 102

Holotype: MSNB 3156.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Pinna (1974) reported one specimen (MSNB 3156) from Cene (Bergamo).

Parvocaris Bravi & Garassino, 1998

Type species: *Parvocaris samnitica* Bravi & Garassino, 1998.
Stratigraphic range: Lower Cretaceous (Albian).

Parvocaris samnitica Bravi & Garassino, 1998

1998a – *Parvocaris samnitica* Bravi & Garassino; p. 154, Text-figs. 24-25
1998b – *Parvocaris samnitica* Bravi & Garassino *in* Bravi & Garassino; p. 109
1998 – *Parvocaris samnitica* Bravi & Garassino *in* Garassino; p. 67
1999 – *Parvocaris samnitica* Bravi & Garassino *in* Bravi, Coppa, Garassino & Patricelli; p. 162
2001 – *Parvocaris samnitica* Bravi & Garassino *in* Garassino & Teruzzi; p. 151
2002 – *Parvocaris samnitica* Bravi & Garassino *in* Garassino, Schram, Taylor & Shen; p. 76
2003 – *Parvocaris samnitica* Bravi & Garassino *in* Garassino & Bravi; p. 590
2005 – *Parvocaris samnitica* Bravi & Garassino *in* Garassino & Jakobsen; p. 102

Holotype: M 20545.
Stratigraphic range: Lower Cretaceous (Albian).
Occurrence: Campania.
Material: Bravi & Garassino (1998a) reported 14 specimens (M 19309, 19334, 19344, 19373, 19389, 20525, 20545, 20571, 20723, 20772, 20773, St5/29, St7/7, St7/8) from Pietraroia (Benevento).

Pinnacaris Garassino & Teruzzi, 1993

Type species: *Pinnacaris dentata* Garassino & Teruzzi, 1993.

Stratigraphic range: Upper Triassic (Norian).

Pinnacaris dentata Garassino & Teruzzi, 1993

1993 – *Pinnacaris dentata* Garassino & Teruzzi; p. 12, Text-figs. 18-19, Pl. 2 (fig. 4)
1996 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino & Teruzzi; p. 8
1997 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino; p. 107
1998a – *Pinnacaris dentata* Garassino & Teruzzi *in* Bravi & Garassino; p. 155
1998b – *Pinnacaris dentata* Garassino & Teruzzi *in* Bravi & Garassino; p. 108
1998 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino; p. 65
1999 – *Pinnacaris dentata* Garassino & Teruzzi *in* Bravi, Coppa, Garassino & Patricelli; p. 161
2001 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino & Teruzzi; p. 150
2002 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino, Schram, Taylor & Shen; p. 76
2003 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino & Bravi; p. 590
2005 – *Pinnacaris dentata* Garassino & Teruzzi *in* Garassino & Jakobsen; p. 102

Holotype: MSNM i10691-i10692 (part and counterpart).
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported four specimens (MSNB 7693, 7731; MSNM i10691-i10692, i10693) from Ponte Giurino (Bergamo).

Indeterminates
Indeterminate caridean

1995 – Indeterminate caridean *in* Garassino & Teruzzi; p. 83, Text-fig. 3

Stratigraphic range: Lower Cretaceous (Hauterivian-Barremian).
Occurrence: Friuli Venezia-Giulia.
Material: Garassino & Teruzzi (1995) reported two specimens (MFSN 4309, 4316) from Vernasso (Udine).

Caridean genus et species indeterminate

1996 – Caridean gen. et sp. indet. *in* Garassino, Teruzzi & Dalla Vecchia; p. 32, Text-fig. 16

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Friuli Venezia-Giulia.
Material: Garassino *et al.* (1996) reported one specimen (MFSN 16140) from Caprizzi (Udine).

Infraorder Astacidea Latreille, 1802
Family Glypheidae Zittel, 1885

Glyphea v. Meyer, 1835

Type species: *Palinurus regleyanus* Desmarest, 1822.
Stratigraphic range: Upper Triassic (Carnian) – Eocene (Bartonian).

Glyphea rigoi Garassino, 2000

1996 – *Glyphea* sp. *in* Garassino, Teruzzi & Dalla Vecchia; p. 43
2000a – *Glyphea rigoi* Garassino; p. 61, Text-fig. 1

Holotype: MFSN 22976.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Friuli-Venezia Giulia.
Material: Garassino *et al.* (1996) reported five specimens (MFSN 1414 a-b, 1953, 1954, 16095 a-b, 16182) from Caprizzi and Rio Seazza (Udine); Garassino (2000a) reported one specimen (MFSN 22976) from Caprizzi (Udine).

Glyphea tonelloi Garassino, 1997

1997 – *Glyphea tonelloi* Garassino; p. 87, Text-figs. 2-5

Holotype: MFSN 19863.
Stratigraphic range: Lower Cretaceous (Barremian – Aptian).
Occurrence: Friuli-Venzia Giulia.
Material: Garassino (1997) reported four specimens (MFSN 19859, 19861, 19862, 19863) from Torrente Cornappo (Udine).

Glyphea tricarinata Garassino, 1996

1996 – *Glyphea tricarinata* Garassino; p. 341, Text-figs. 6-8, 22-25

Holotype: MSNM i7609.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino (1996) reported 137 specimens (the best specimens are: MSNM i7609, i9938, i9942, i9944, i9946, i9963, i9967, i9970, i9980, i9997, i10007, i10451, i10455) from Osteno (Como).

†Family Mecochiridae Van Straelen, 1925

Mecochirus Germar, 1827

Type species: *Macrourites longimanatus* Schlotheim, 1820.
Stratigraphic range: Lower Jurassic (Sinemurian) – Upper Cretaceous (Maastrichtian).

Mecochirus germari Garassino, 1996

1996 – *Mecochirus germari* Garassino; p. 346, Text-figs. 9-10, 26-29

Holotype: MSNM i13521 a-b.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino (1996) reported 81 specimens (the best specimens are: MSNM i10119, i10121, i10124, i12132 a-b, i10136, i10139, i10141, i10172, i10294, i10920, i13520, i13521 a-b) from Osteno (Como).

Pseudoglyphea Oppel, 1861

Type species: *Glyphea grandis* v. Meyer, 1837.

Stratigraphic range: Upper Triassic (Carnian) – Upper Jurassic (Oxfordian).

Pseudoglyphea ancylochelis (Woodward, 1863)

1863 – *Scapheus ancylochelis* Woodward; p. 319, Text-fig. 11
1924 – *Scapheus ancylochelis* Woodward *in* Van Straelen; p. 224, Text-fig. 3
1925 – *Scapheus ancylochelis* Woodward *in* Van Straelen; p. 210, Text-fig. 104, Pl. 7 (fig. 2)
1925 – *Pseudoglyphea ancylochelis* (Woodward) *in* Woods; p. 46, Pl. 12 (figs. 2-3)
1929 – *Pseudoglyphea ancylochelis* (Woodward) *in* Glaessner; p. 353
1996 – *Pseudoglyphea ancylochelis* (Woodward) *in* Garassino; p. 349, Text-figs. 11-14, 30-31

Holotype: NHM 46322.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino (1996) reported seven specimens (MSNM i10149, i10169, i10254, i10256-i10293, i10258, i10264, i10295) from Osteno (Como).
Note: this species is also reported from the Lower Jurassic (Sinemurian) of Lyme Regis (Great Britain).

Pseudoglyphea gigantea Garassino & Teruzzi, 1993

1993 – *Pseudoglyphea gigantea* Garassino & Teruzzi; p. 14, Text-figs. 20-28, Pl. 3 (figs. 1-4)

Holotype: MSNM i10678-i10679 (part and counterpart).
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported 183 specimens (the best specimens are: MSNB 7648, 7561, 7558-7554, 7624, 7659-7661, 7573, 7620-7621, 7562-7702, 7610, 7684, 8252, 8336, 8241, 8348, 8321; MSNM from i10676 to i10681, i10689-i10690) from Ponte Giurino (Bergamo).

Pseudoglyphea paronae (Colosi, 1921)

1921 – *Heteroglyphea paronae* Colosi; p. 81, Text-figs. 1-2
1924 – *Pseudoglyphea paronae* (Colosi) *in* Van Straelen; p. 226, Text-fig. 6
1925 – *Pseudoglyphea paronae* (Colosi) *in* Van Straelen; p. 205
1929 – *Pseudoglyphea paronai* (Colosi) *in* Glaessner; p. 356
1969 – *Pseudoglyphea paronae* (Colosi) *in* Glaessner; p. 466
1996 – *Pseudoglyphea paronae* (Colosi) *in* Garassino; p. 353

Holotype: lost.
Stratigraphic range: Jurassic.
Occurrence: Liguria.
Material: Colosi (1921) reported one specimen from La Spezia, today lost.

†Family Erymidae Van Straelen, 1924

Eryma v. Meyer, 1840

Type species: *Macrourites modestiformis* Schlotheim, 1822.

Stratigraphic range: Lower Jurassic (Sinemurian) – Upper Cretaceous (Cenomanian).

Eryma meyeri Garassino, 1996

1996 – *Eryma meyeri* Garassino; p. 335, Text-figs. 1-3, 15-17

Holotype: MSNM i7606.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Garassino (1996) reported 41 specimens (the best specimens are: MSNM i7606, i7607, i9871, i9875, i9884, i9886, i9893, i9895, i9896, i9902, i9915, i9916, i10265, i10635, i10656) from Osteno (Como).

?*Eryma rinellincola* De Gregorio, 1884

1884 – ?*Eryma rinellincola* De Gregorio; p. 134
1929 – *Eryma rinellincola* De Gregorio *in* Glaessner; p. 159

Holotype: lost.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: De Gregorio (1884) reported one specimen from Contrada Rotoli (Palermo), today lost.

Pustulina Quenstedt, 1857

Type species: *Pustulina suevica* Quenstedt, 1857.
Stratigraphic range: Lower Jurassic (Sinemurian) – Upper Cretaceous (Campanian – Maastrichtian).

Pustulina sinemuriana (Garassino, 1996)

1996 – *Phlyctisoma sinemuriana* Garassino; p. 338, Text-figs. 4-5, 18-21

Holotype: MSNM i13517.
Stratigraphic range: Lower Jurassic (Sinemurinan).
Occurrence: Lombardia.
Material: Garassino (1996) reported ten specimens (the best specimens are: MSNM i7608-i9911, i9907-i9887, i9909-i9873, i10450, i13517) from Osteno (Como).

Family Nephropidae Dana, 1852

Hoploparia McCoy, 1849

Type species: *Astacus longimanus* Sowerby, 1826.
Stratigraphic range: Lower Cretaceous (Hauterivian) – Miocene.

Hoploparia sp.

1889 – *Hoploparia* sp. *in* Ristori; p. 411, Pl. 15 (fig. 19)
1929 – *Hoploparia* sp. *in* Glaessner; p. 223

Stratigraphic range: Miocene.
Occurrence: Liguria.
Material: Ristori (1889) reported two specimens from Mioglia and S. Giustina (Savona), housed in don Perrando's collection, today lost.

Hoploparia sp.

2005 – *Hoploparia* sp. *in* Beschin, De Angeli, Checchi & Zarantonello; p. 7, Text-fig. 2, Pl. 1 (fig. 1 a-c)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported one specimen (MCZ 2360) from Grola di Cornedo Vicentino (Vicenza).

Metanephrops Jenkins, 1972

Type species: *Nephrops japonicus* Tapparone-Canefri, 1873.
Stratigraphic range: Upper Cretaceous (Maastrichtian) – Recent.

Metanephrops sp.

2003 – *Metanephrops* sp. *in* Garassino, De Angeli & De Polli; p. 387, Text-figs. 4-5

Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Garassino *et al.* (2003) reported one specimen (MSNM i26261) from "Fontanella" di Grancona (Vicenza).

Nephropsis Wood-Mason, 1873

Type species: *Nephropsis stewarti* Wood-Mason, 1873.
Stratigraphic range: Eocene – Recent.

Nephropsis sp.

2004a – *Nephropsis* sp. *in* Garassino & De Angeli; p. 35, Text-fig. 2

Stratigraphic range: Pleistocene.
Occurrence: Emilia Romagna.
Material: Garassino & De Angeli (2004a) reported one specimen (MG 0620) from Fiume Enza (Parma).

†Family Platychelidae Glaessner, 1969

Glaessnericaris Garassino & Teruzzi, 1993

Type species: *Glaessnericaris macrochela* Garassino & Teruzzi, 1993.
Stratigraphic range: Upper Triassic (Norian).

Glaessnericaris dubia (Pinna, 1974)

1974 – ***Protoclytiopsis dubia* Pinna**; p. 26, Pl. 1 (figs. 1-3), Pl. 16 (figs. 1-3)
1993 – *Glaessnericaris dubia* (Pinna) *in* Garassino & Teruzzi; p. 24

Holotype: MSNB 3186.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Pinna (1974) reported nine specimens (MSNB 3186, 3187, 3188, 3155, 3183, 3194; MSNM i4475, i4479) from Cene (Bergamo).

Glaessnericaris macrochela Garassino & Teruzzi, 1993

1993 – *Glaessnericaris macrochela* Garassino & Teruzzi; p. 21, Text-figs. 41-48, Pl. 5 (figs. 1-4)

Holotype: MSNB 4202.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (1993) reported 310 specimens (the best specimens are: MSNB 4202, 4205, 4208, 7564, 7556-7553, 7591, 7701, 7583-7627, 7622, 7679, 7642, 7640, 7652, 7672, 7732, 7557, 7572, 7559 a-b, 7708-7710, 8214, 8315, 8249, 8237; MSNM i10732, i10727, i10736, i10731) from Ponte Giurino (Bergamo).

Glaessnericaris sp.

1996 – *Glaessnericaris* sp. *in* Garassino, Teruzzi & Dalla Vecchia; p. 44

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Friuli-Venzia Giulia.
Material: Garassino *et al.* (1996) reported one specimen (MFSN 16146 a-b) from Caprizzi (Udine).

†Family Uncinidae Beurlen, 1928

Uncina Quenstedt, 1851

Type species: *Uncina posidoniae* Quenstedt, 1851.
Stratigraphic range: Lower Jurassic (Sinemurian/Pliensbachian – Toarcian).

Uncina alpina Schweigert, Garassino, Hall, Hauff & Karasawa, 2003

2001 – *Uncina* cfr. *U. posidoniae* Quenstedt *in* Garassino & Teruzzi; p. 189, Text-fig. 2
2003 – *Uncina alpina* Schweigert, Garassino, Hall, Hauff & Karasawa; p. 9, Text-fig. 5 a, Pl. 10 (figs. 1-5)

Holotype: MSNM i10864.
Stratigraphic range: Lower Jurassic (Toarcian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (2001) reported three specimens (MSNM i10851, i10863, i10864) from Sogno (Bergamo); Schweigert *et al.* (2003) described this species on the three specimens previously studied by Garassino & Teruzzi.

Indeterminates
Family, genus et species indeterminate

1996 – Family, gen. et sp. indet. *in* Garassino, Teruzzi & Dalla Vecchia; p. 44, Text-fig. 23

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Friuli Venezia-Giulia.
Material: Garassino *et al.* (1996) reported one specimen (MFSN 1413) from Caprizzi (Udine).

Family, genus et species indeterminate

1998a – Family, gen. et sp. indet. *in* Bravi & Garassino; p. 156

Stratigraphic range: Lower Cretaceous (Albian).
Occurrence: Campania.
Material: Bravi & Garassino (1998a) reported two specimens (M 20547, 20724) from Pietraroia (Benevento).

Family ?Platichelidae, genus et species indeterminate

1996 – Family ?Platichelidae, gen. et sp. indet. *in* Garassino, Teruzzi & Dalla Vecchia; p. 45, Text-fig. 24

Stratigraphic range: Upper Triassic (Norian).
Occurrence: Friuli Venezia-Giulia.
Material: Garassino *et al.* (1996) reported one specimen (MFSN 16170 a-b) from Monte Auda (Udine).

Genus et species indeterminate

1999 – Gen. et sp. indet. *in* Garassino; p. 63, Text-fig. 1

Stratigraphic range: Lower Cretaceous (Hauterivian–Barremian).
Occurrence: Friuli Venezia-Giulia.
Material: Garassino (1999) reported two specimens (MFSN 22977, 22978 a-b) from Vernasso (Udine).

Infraorder Thalassinidea Latreille, 1831
Superfamily Thalassinoidea Latreille, 1831
Family Thalassinidae Latreille, 1831

Thalassina Latreille, 1806

Type species: *Thalassina scorpionides* Latreille, 1806.
Stratigraphic range: Pleistocene – Recent.

Thalassina sp.

1891a – *Thalassina* sp. *in* Ristori; p. 14, Pl. 1 (figs. 16-17)

Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1891a) reported two specimens from Spicchio (Empoli), today lost.

Superfamily Callianassoidea Dana, 1852
Family Callianassidae Dana, 1852

Callianassa Leach, 1814

Type species: *Cancer* (*Astacus*) *subterraneus* Montagu, 1808.
Stratigraphic range: Upper Cretaceous – Recent.

Callianassa calaritana Ristori, 1896

1896 – *Callianassa calaritana* Ristori; p. 512, Pl. 12 (fig. 9)
1902 – *Callianassa calaritana* Ristori *in* Lovisato; p. 8
1909 – *Callianassa calaritana* Ristori *in* Lörenthey; p. 218
1929 – *Callianassa calaritana* Ristori *in* Glaessner; p. 77
1950 – *Callianassa calaritana* Ristori *in* Comaschi Caria; p. 326
1956 – *Callianassa calaritana* Ristori *in* Comaschi Caria; p. 288

Holotype: lost.
Stratigraphic range: Pleistocene.
Occurrence: Sardegna.
Material: Ristori (1896) reported one specimen from S. Avendrace (Cagliari), today lost; Lovisato (1902) reported some specimens from S. Bartolomeo (Cagliari) (repository and catalogue number unknown); Lörenthey (1909) reported one specimen from S. Avendrace (Cagliari) (repository and catalogue number unknown).

Callianassa canavarii Ristori, 1889

1889 – *Callianassa canavarii* Ristori; p. 409, Pl. 15 (figs. 17-18)
1929 – *Callianassa canavarii* Ristori *in* Glaessner; p. 77
1974 – *Callianassa canavarii* Ristori *in* Mastrorilli; p. 4

Holotype: lost.
Stratigraphic range: Oligocene.
Occurrence: Liguria.
Material: Ristori (1889) reported two specimens from S. Giustina and Sassello (Savona), housed in don Perrando's collection, today lost.

Callianassa desmarestiana A. Milne Edwards, 1860

1829 – *Pagurus desmarestianus* de Serres (*nomen nudum*); p. 154
1860 – *Callianassa desmarestiana* A. Milne Edwards; p. 335, Pl. 13 (fig. 4)
1888 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Ristori; p. 217, Pl. 4 (figs. 12-13)
1896 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Ristori; p. 513
1902 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Lovisato; p. 7
1909 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Lörenthey; p. 213, Pl. 1 (figs. 3-4)
1929 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Glaessner; p. 79
1950 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Comaschi Caria; p. 326
1956 – *Callianassa desmarestiana* (A. Milne Edwards) *in* Comaschi Caria; p. 288

Holotype: unknown.
Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Ristori (1888) reported some specimens from S. Bartolomeo (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown); Ristori (1896) reported one specimen from Bosa (Nuoro) (repository and catalogue number unknown); Lovisato (1902) reported some specimens from S. Bartolomeo (Cagliari) (repository and catalogue number unknown); Lörenthey (1909) reported one specimen from S. Bartolomeo (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).
Note: this species is also reported from the Miocene of France.

Callianassa cfr. *C. ferox* Bittner, 1893

2005 – *Callianassa* cfr. *C. ferox* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 8, Pl. 1 (figs. 2-3)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported two specimens (MCZ 2371, 2372) from Grola di Cornedo Vicentino (Vicenza).

Callianassa michelotti A. Milne Edwards, 1860

1860 – *Callianassa michelotti* A. Milne Edwards; p. 341, Pl. 14 (fig. 3)
1871 – *Callianassa michelotti* A. Milne Edwards *in* Fritsch; p. 691, Pl. 17 (figs. 5-13)
1886 – *Callianassa michelotti* A. Milne Edwards *in* Noetling; p. 84, Pl. 5 (fig. 4)
1895 – *Callianassa michelotti* A. Milne Edwards *in* Crema; p. 667, Text-fig. 3
1903 – *Callianassa michelotti* A. Milne Edwards *in* Kinkelin; p. 31
1928 – *Callianassa michelotti* A. Milne Edwards *in* Glaessner; p. 167
1929 – *Callianassa michelotti* A. Milne Edwards *in* Glaessner; p. 85

Holotype: MNHN B32690.
Stratigraphic range: lower Oligocene (Rupelian) – Miocene.
Occurrence: Piemonte.
Material: A. Milne Edwards (1860) reported one specimen (MNHN B32690) from Superga (Torino); Crema (1895) reported some specimens from Torino (repository and catalogue number unknown).
Note: this species is also reported from the Oligocene of Germany and the Miocene of Austria.

Callianassa pedemontana Crema, 1895

1895 – *Callianassa pedemontana* Crema; p. 665, Text-fig. 1 a-b
1909 – *Callianassa pedemontana* Crema *in* Lörenthey; p. 220
1929 – *Callianassa pedemontana* Crema *in* Glaessner; p. 87

Holotype: lost.
Stratigraphic range: Miocene.
Occurrence: Piemonte, Sardegna.
Material: Crema (1895) reported one specimen from Torino, today lost; Lörenthey (1909) reported one specimen from Coroneddu (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Callianassa cfr. *C. rakosiensis* Lörenthey, 1898

1909 – *Callianassa* cfr. *C. rakosiensis* Lörenthey *in* Lörenthey; p. 217
1929 – *Callianassa* cfr. *C. rakosiensis* Lörenthey *in* Glaessner; p. 89

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported some specimens from Torralba (Sassari) (repository and catalogue number unknown).

Callianassa rovasendae Crema, 1895

1895 – *Callianassa rovasendae* Crema; p. 666, Text-fig. 2 a-b
1929 – *Callianassa rovasendae* Crema *in* Glaessner; p. 89

Holotype: lost.
Stratigraphic range: Miocene.
Occurrence: Piemonte.
Material: Crema (1895) reported one specimen from Baldissero (Torino), today lost.

Callianassa sismondai A. Milne Edwards, 1860

1846 – *Grapsus* sp. *in* E. Sismonda; p. 69, Pl. 3 (fig. 7)
1860 – *Callianassa sismondai* A. Milne Edwards; p. 342, Pl. 14 (fig. 4)
1861 – *Callianassa sismondae* A. Milne Edwards *in* E. Sismonda; p. 21
1895 – *Callianassa sismondae* A. Milne Edwards *in* Crema; p. 667, Text-figs. 4-6, 7 a-b
1928 – *Callianassa sismondae* A. Milne Edwards *in* Glaessner; p. 168
1929 – *Callianassa sismondae* A. Milne Edwards *in* Glaessner; p. 90

Holotype: MNHN B32689.
Stratigraphic range: Miocene.
Occurrence: Piemonte.
Material: A. Milne Edwards (1860) reported one specimen (MNHN B32689) from Torino; E. Sismonda (1861) reported some specimens from Torino (repository and catalogue number unknown); Crema (1895) reported some specimens from Torino (repository and catalogue number unknown).
Note: E. Sismonda (1846) reported one specimen from Torino, ascribing it to *Grapsus* and later E. Sismonda (1861) ascribed the same specimen to *Callianassa sismondai*. This species is also reported from the Miocene of Austria.

Callianassa subterranea (Montagu, 1808)

1808 – *Callianassa subterranea* Montagu; p. 88, Pl. 3 (figs. 1-2)
1895 – *Callianassa subterranea* Montagu *in* Crema; p. 669, Text-fig. 8 a-b
1909 – *Callianassa subterranea* Montagu *in* Lörenthey; p. 219, Pl. 1 (fig. 11)
1929 – *Callinassa subterranea* Montagu *in* Glaessner; p. 91

Holotype: unknown.
Stratigraphic range: Miocene.
Occurrence: Piemonte, Sardegna.
Material: Crema (1895) reported one specimen from Albugnano (Asti) (repository and catalogue number unknown); Lörenthey (1909) reported one specimen from Alghero (Sassari) (repository and catalogue number unknown).

Callianassa subterranea var. *dentata* Ristori, 1891

1891b – *Callianassa subterranea* var. *dentata* Ristori; p. 24, Pl. 1 (figs. 19-20)
1895 – *Callianassa subterranea* var. *dentata* Ristori *in* Crema; p. 670
1914 – *Callianassa subterranea* var. *dentata* Ristori *in* M. Gemmellaro; p. 94, Pl. 1 (figs. 31-32)
1929 – *Callianassa subterranea* var. *dentata* Ristori *in* Glaessner; p. 91
1981 – *Callianassa subterranea* var. *dentata* Ristori *in* Varola; p. 10, Pl. 1 (figs. 1-2, 4), Pl. 2 (figs. 1, 3-4)

Stratigraphic range: Miocene – Pleistocene (Sicilian).
Occurrence: Piemonte, Lazio, Puglia, Sicilia.
Material: Ristori (1891b) reported one specimen from

Astura (Roma), housed in Clerici's collection (repository and catalogue number unknown); Crema (1895) reported some specimens from Torino (repository and catalogue number unknown); M. Gemmellaro (1914) reported two specimens from Monte Pellegrino (MGUP, catalogue number unknown); Varola (1981) reported one specimen from Porto Craulo (Otranto) (GNSL, catalogue number unknown).

Callianassa sp.

1889 – *Callianassa* sp. *in* Ristori; p. 410
1929 – *Callianassa* sp. *in* Glaessner; p. 96
1974 – *Callianassa* sp. *in* Mastrorilli; p. 4

Stratigraphic range: Miocene.
Occurrence: Liguria.
Material: Ristori (1889) reported many specimens from S. Giustina and Sassello (Savona), today lost.

Callianassa sp.

1895 – *Callianassa* sp. *in* Crema; p. 670, Text-figs. 9 a-b, 10 a-b
1929 – *Callianassa* sp. *in* Glaessner; p. 96

Stratigraphic range: Miocene.
Occurrence: Piemonte.
Material: Crema (1895) reported some specimens from Torino, Sciolze and Baldissero (Torino), today lost.

Callianassa sp.

1909 – *Callianassa* sp. *in* Lörenthey; p. 222
1929 – *Callianassa* sp. *in* Glaessner; p. 96

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material Lörenthey (1909) reported some specimens from S. Lorenzo di Nulvi (Sassari) (repository and catalogue number unknown).

Callianassa sp.

1991 – *Callianassa* sp. *in* Marras & Ventura; p. 107, Pl. 2 (fig. 3)

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Marras & Ventura (1991) reported one specimen from Sassari (repository and catalogue number unknown).

Corallianassa Manning, 1987

Type species: *Callianassa longiventris* A. Milne Edwards, 1870.
Stratigraphic range: Upper Cretaceous – Recent.

Corallianassa rigoi De Angeli & Garassino, 2006

2006a – *Corallianassa rigoi* De Angeli & Garassino; p. 270, Text-figs. 2, 3 (a-c)

Holotype: MSNM i26581.
Stratigraphic range: Cretaceous (Aptian–Campanian).
Occurrence: Friuli-Venezia Giulia.
Material: De Angeli & Garassino (2006a) reported six specimens (MSNM from i26578 to i26583) from Monte Ciaurlec (Pordenone).

Eoglypturus Beschin, De Angeli, Checchi & Zarantonello, 2005

Type species: *Eoglypturus grolensis* Beschin, De Angeli, Checchi & Zarantonello, 2005.
Stratigraphic range: middle Eocene (Lutetian).

Eoglypturus grolensis Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Eoglypturus grolensis* Beschin, De Angeli, Checchi & Zarantonello; p. 10, Text-fig. 5, Pl. 1 (fig. 6 a-b)

Holotype: MCZ 2381 (I.G. 296600).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported one specimen (MCZ 2381) from Grola di Cornedo Vicentino (Vicenza).

Eucalliax Manning & Felder, 1991

Type species: *Callianassa quadracuta* Biffar, 1970.
Stratigraphic range: Eocene – Recent.

Eucalliax vicetina Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Eucalliax vicetina* Beschin, Busulini, De Angeli & Tessier; p. 10, Text-fig. 4, Pl. 1 (figs. 1-3)
2004 – *Eucalliax vicetina* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Eucalliax vicetina* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 9, Text-fig. 4, Pl. 1 (fig. 5)

Holotype: MCZ 2259 (I.G. 296387).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported five specimens (MCZ 1187, 2259, 2260, 2261, 2262) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2363) from Grola di Cornedo Vicentino (Vicenza).

Neocallichirus Sakai, 1988

Type species: *Neocallichirus horneri* Sakai, 1988.
Stratigraphic range: Eocene – Recent.

Neocallichirus allegranzii Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Neocallichirus allegranzii* Beschin, De Angeli, Checchi & Zarantonello; p. 8, Text-fig. 3, Pl. 1 (figs. 7-8)

Holotype: MCZ 2318 (I.G. 296537).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.

Material: Beschin *et al.* (2005) reported seven specimens (MCZ 2281, 2282, 2306, 2318, 2321, 2329, 2385) from Grola di Cornedo Vicentino (Vicenza).

Neocallichirus borensis Beschin, De Angeli, Checchi & Mietto, 2006

2006 – *Neocallichirus borensis* Beschin, De Angeli, Checchi & Mietto; p. 97, Text-fig. 2, Pl. (figs. 4 a-b, 5-6)

Holotype: MCZ 2423.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (2006) reported ten specimens (MCZ from 2423 to 2428, from 2450 to 2453) from Mulino del Boro (Vicenza).

Neocallichirus fortisi Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Neocallichirus fortisi* Beschin, Busulini, De Angeli & Tessier; p. 9, Text-fig. 3, Pl. 1 (fig. 4 a-c)
2004 – *Neocallichirus fortisi* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Neocallichirus fortisi* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 8, Pl. 1 (fig. 4)

Holotype: MCZ 2258 (I.G. 296386).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported two specimens (MCZ 2258 a-b) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2328) from Grola di Cornedo Vicentino (Vicenza).

Neocallichirus sp.

1995 – *Callianassa* sp. *in* De Angeli; p. 10, Text-fig. 2 (1), Pl. 1 (figs. 1-2)
2001 – *Callianassa* sp. *in* De Angeli & Beschin; p. 10
2006 – *Neocallichirus* sp. *in* Beschin, De Angeli, Checchi & Mietto; p. 98, Text-fig. 3, Pl. 1 (figs. 1-3)

Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli (1995) reported four specimens (MCZ from 1486 to 1489) from "Fontanella" di Grancona (Vicenza); Beschin *et al.* (2006) reported three specimens (MCZ 2420, 2421, 2422) from Buso della Rana (Vicenza).

Family Ctenochelidae Manning & Felder, 1991

Callianopsis de Saint Laurent, 1973

Type species: *Callianassa goniophthalma* Rathbun, 1902.
Stratigraphic range: Eocene – Recent.

Callianopsis microspineus Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Callianopsis microspineus* Beschin, De Angeli, Checchi & Zarantonello; p. 11, Text-fig. 7, Pl. 2 (fig. 1 a-b)

Holotype: MCZ 2373 (I.G. 296592).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported two specimens (MCZ 2323, 2373) from Grola di Cornedo Vicentino (Vicenza).

Ctenocheles Kishinouye, 1926

Type species: *Ctenocheles balssi* Kishinouye, 1926.
Stratigraphic range: Upper Cretaceous – Recent.

Ctenocheles ornatus Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Ctenocheles ornatus* Beschin, De Angeli, Checchi & Zarantonello; p. 10, Text-fig. 6, Pl. 1 (figs. 9-11)

Holotype: MCZ 2334 (I.G. 296553).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported five specimens (MCZ 2283, 2309, 2310, 2332, 2334) from Grola di Cornedo Vicentino (Vicenza).

Ctenocheles valdellae (Fabiani, 1908)

1905 – *Ilia* sp. *in* Fabiani; p. 32
1908 – *Ilia? Valdellae* Fabiani; p. 211, 236, Pl. 6 (fig. 15)
1910a – *Ilia Valdellae* Fabiani *in* Fabiani; p. 21, 33
1915 – *Ilia Valdellae* Fabiani *in* Fabiani; p. 284, 285
1929 – *Ilia valdellae* Fabiani *in* Glaessner; p. 225
1998 – *Ctenocheles valdellae* (Fabiani) *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 15
2001 – *Ctenocheles valdellae* (Fabiani) *in* De Angeli & Beschin; p. 10
2005 – *Ctenocheles valdellae* (Fabiani) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 11

Holotype: MGPD 23453.
Stratigraphic range: lower/middle Eocene, lower Oligocene.
Occurrence: Veneto.
Material: Fabiani (1908, 1910a) reported two specimens (MGPD 23453, 23454) from Colle Valdella di Nanto, Montruglio, and Monte Berico (Vicenza).

Ctenocheles sp.

1995 – *Ctenocheles* sp. *in* De Angeli; p. 10, Text-fig. 2 (3 a-c), Pl. 1 (fig. 3)
1998 – *Ctenocheles* sp. *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 15, Text-figs. 5, 6 (1)
2000 – *Ctenocheles* sp. *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Ctenocheles* sp. *in* De Angeli & Beschin; p. 10
2006 – *Ctenocheles* sp. *in* Beschin, De Angeli, Checchi & Mietto; p. 99

Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: De Angeli (1995) reported one specimen (MCZ 1490) from "Fontanella" di Grancona (Vicenza); Beschin *et al.* (1998) reported one specimen (MCZ

1484) from "Rossi" quarry of Monte di Malo (Vicenza); Beschin *et al.* (2006) reported one specimen (MCZ 2429) from Buso della Rana (Vicenza).

Family Laomediidae Borrodaile, 1903

Jaxea Nardo, 1847

Type species: *Jaxea nocturna* Nardo, 1847.
Stratigraphic range: Miocene – Recent.

Jaxea cfr. *J. nocturna* Nardo, 1847

1988a – *Jaxea* cfr. *nocturna* Nardo *in* Delle Cave; p. 3, Pl. 1 (figs. 1-3), Pl. 2 (figs. 1-3)
1993 – *Jaxea* cfr. *nocturna* Nardo *in* Müller; p. 5, Text-fig. 3 C, D
1998 – *Jaxea* cfr. *nocturna* Nardo *in* Mayoral, Müller & Muñiz; p. 507, Text-fig. 2 (2)

Stratigraphic range: lower Pliocene.
Occurrence: Toscana.
Material: Delle Cave (1988a) reported ten specimens (IGF 1018E, 1019E, 1022E, 1033E, 1624E, 1629E, 1632E, 2441E, 2442E, 2476E) from Castelfiorentino (Firenze).

Family Upogebiidae Borradaile, 1903

Upogebia Leach, 1814

Type species: *Gebia stellata* Montagu, 1808.
Stratigraphic range: Jurassic – Recent.

Upogebia perarolensis De Angeli & Messina, 1992

1992 – *Upogebia perarolensis* De Angeli & Messina; p. 185, Text-fig. 1, Pl. 1 (figs. 1-2); Pl. 2 (figs. 1-2)
2001 – *Upogebia perarolensis* De Angeli & Messina *in* De Angeli & Beschin; p. 11, Text-figs. 5- 6
2006 – *Upogebia perarolensis* De Angeli & Messina *in* De Angeli & Rossi; p. 90, Pl. 2 (figs. 1, 3)

Holotype: MCZ 1363 (I.G. 284580).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli & Messina (1992) reported 12 specimens (MCZ from 1363 to 1374) from Perarolo (Vicenza).

Upogebia cfr. *U. stellata* (Montagu, 1808)

1891b – *Upogebia* cfr. *stellata* (Montagu) *in* Ristori; p. 24
1914 – *Gebia* cfr. *stellata* (Montagu) *in* M. Gemmellaro; p. 93, Pl. 1 (figs. 29-30)
1929 – *Upogebia* cfr. *U. stellata* (Montagu) *in* Glaessner; p. 392

Stratigraphic range: Pliocene – upper Pleistocene (Sicilian).
Occurrence: Lazio, Sicilia.
Material: Ristori (1891b) reported three specimens from Farnesina (Roma), housed in Clerici's collection, today lost; M. Gemmellaro (1914) reported some specimens from Ficarazzi (Palermo) (MGUP, catalogue number unknown) and in the Marchese di Monterosato's collection (repository and catalogue number unknown).

Family Axiidae Huxley, 1879

Etallonia Oppel, 1861

Type species: *Magila longimana* Münster, 1839.
Stratigraphic range: Lower Jurassic (Toarcian) – Upper Jurassic (Tithonian).

Etallonia sp.

2001 – *Etallonia* sp. *in* Garassino & Teruzzi; p. 191, Text-fig. 4

Stratigraphic range: Lower Jurassic (Toarcian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (2001) reported one specimen (MSNM i10855) from Sogno (Bergamo).
Note: Garassino & Schweigert (2006) suggested that this specimen probably could be ascribed to *Megachela* Schweigert, 2003.

Huxleycaris Bravi & Garassino, 1998

Type species: *Huxleycaris beneventana* Bravi & Garassino, 1998.
Stratigraphic range: Lower Cretaceous (Albian).

Huxleycaris beneventana Bravi & Garassino, 1998

1998a – *Huxleycaris beneventana* Bravi & Garassino; p. 157, Text-figs. 26-29

Holotype: M 20885 (N° 1).
Stratigraphic range: Lower Cretaceous (Albian).
Occurrence: Campania.
Material: Bravi & Garassino (1998a) reported 12 specimens (M 20885: this catalogue number indicates some specimens, preserved on the same layer surface; the best specimens were marked by the following Arabic numbers, 1, 2, 3, 4, 5, 9) from Pietraroia (Benevento).

Protaxius Beurlen, 1930

Type species: *Callianassa isochela* Woodward, 1876.
Stratygraphic range: Upper Jurassic – middle Eocene.

Protaxius eocenicus Secretan, 1975

1975 – *Protaxius eocenicus* Secretan; p. 343, Pl. 16 (figs. 1-2, 5)

Holotype: MSNV 4-5 (part and counter-part).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported one specimen (MSNV 4-5) from Monte Bolca (Verona).

Protaxius sp.

1975 – *Protaxius* sp. *in* Secretan; p. 344

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported two specimens (MGPD 10905, 12454) from Monte Bolca (Verona).

Indeterminate family

Orhomalus Etallon, 1861

Type species: *Orhomalus virgulinus* Etallon, 1861.
Stratigraphic range: Middle Jurassic – ?Lower Cretaceous.

Orhomalus rotulensis De Gregorio, 1884

1884 – *Orhomalus rotulensis* De Gregorio; p. 134
1929 – *Orhomalus rotulensis* De Gregorio *in* Glaessner; p. 283

Holotype: unknown.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: De Gregorio (1884) reported one specimen from Contrada Rotoli (Palermo) (repository and catalogue number unknown).

Infraorder Palinura Latreille, 1803
†Family Coleiidae Van Straelen, 1924

Coleia Broderip, 1835

Type species: *Coleia antiqua* Broderip, 1835.
Stratigraphic range: Upper Triassic (Carnian) – Lower Cretaceous (Neocomian).

Coleia boboi Garassino & Gironi, 2006

2006 – *Coleia boboi* Garassino & Gironi; p. 95, Text-figs. 2-6

Holotype: MFSN 20911 a-b.
Stratigraphic range: Upper Triassic (Rhaetian).
Occurrence: Fiurli-Venezia Giulia.
Material: Garassino & Gironi (2006) reported 47 specimens (MFSN: from 28996 to 29014, from 29016 to 29021, from 29023 to 29031, from 29033 to 29045) from Monte Verzegnis (Udine).

Coleia mediterranea Pinna, 1968

1968 – *Coleia mediterranea* Pinna; p. 123, Text-figs. 9-10, Pls. 13-16
1990 – *Coleia mediterranea* Pinna *in* Teruzzi; p. 96, Text-figs. 11-15

Holotype: MSNM T56.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Pinna (1968) reported one specimen (MSNM T 56) from Osteno (Como); Teruzzi (1990) reported five specimens (MSNM i7656, i7661, i7665, i7690, i7781) from Osteno (Como).

Coleia pinnai Teruzzi, 1990

1990 – *Coleia pinnai* Teruzzi; p. 86, Text-figs. 1-6

Holotype: MSNM i6111.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Teruzzi (1990) reported four specimens (MSNM i6111, i7657, i7659, i7661) from Osteno (Como).

Coleia popeyei Teruzzi, 1990

1990 – *Coleia popeyei* Teruzzi; p. 92, Text-figs. 7-10

Holotype: MSNM i7683.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Teruzzi (1990) reported seven specimens (MSNM i3369, i7683, i7684, i7686, i7687, i7688, i7780) from Osteno (Como).

Coleia viallii Pinna, 1968

1968 – *Coleia viallii* Pinna; p. 112, Text-figs. 5-8, Pl. 3 (fig. 1), Pls. 4-12
1969 – *Coleia viallii* Pinna *in* Pinna; p. 627, Text-figs. 1-4
1990 – *Coleia viallii* Pinna *in* Teruzzi; p. 100, Text-figs. 16-18

Holotype: MSNM T51.
Stratigraphic range: Lower Jurassic (Sinemurian).
Occurrence: Lombardia.
Material: Pinna (1968) reported six specimens (MSNM from T51 to T55, T57) from Osteno (Como); Pinna (1969) reported two specimens (MSNM i46, i47) from Osteno (Como); Teruzzi (1990) reported 46 specimens (the best specimens are: MSNM i7604, i7658, i7704, i7708, i7709) from Osteno (Como).

Proeryon Beurlen, 1928

Type species: *Eryon hartmanni* v. Meyer, 1835.
Stratigraphic range: Lower Jurassic (Toarcian).

Proeryon hartmanni (v. Meyer, 1835)

1835 – *Eryon hartmanni* v. Meyer; p. 329
1836 – *Eryon hartmanni* v. Meyer; p. 263, Pl. 11 (fig. 1), Pl. 12 (figs. 2, 4)
1857 – *Eryon hartmanni* v. Meyer *in* Quenstedt; p. 241, Pl. 34 (fig. 6)
1862 – *Eryon hartmanni* v. Meyer *in* Oppel; p. 11
1891 – *Eryon hartmanni* v. Meyer *in* Krause; p. 183
1891 – *Coleia macrophthalma* Krause; p. 177, Pl. 11 (figs. 1-4), **nov. syn.**
1908 – *Eryon hartmanni* v. Meyer *in* Engel; p. 270
1911 – *Eryon richardsoni* Woodward; p. 309, Text-fig. 2, **nov. syn.**
1925 – *Coleia hartmanni* (v. Meyer) *in* Van Straelen; p. 141
1925 – *Coleia richardsoni* (Woodward) *in* Woods; p. 22, Pl. 6 (fig. 2)
1928 – *Proryon hartmanni* (v. Meyer) *in* Beurlen; p. 193, Text-fig. 20, Pl. 6 (fig. 6)
1928 – *Proeryon macrophthalmus* (Krause) *in* Beurlen; p. 194, Text-fig. 21
1928 – *Proeryon longiceps* Beurlen; p. 196, Text-fig. 22, **nov. syn.**
1928 – *Coleia* n. sp. *in* Beurlen; p. 191
1929 – *Proeryon hartmanni* (v. Meyer) *in* Glaessner; p. 339
1929 – *Proeryon longiceps* Beurlen *in* Glaessner; p. 339
1929 – *Proeryon macrophthalmus* (Krause) *in* Glaessner; p. 340
1944 – *Proeryon longiceps* Beurlen *in* Beurlen; p. 374, Pl. 34 (fig. 1)
1944 – *Proeryon* n. sp.? *in* Beurlen; p. 377, Pl. 34 (fig. 2)

1952 – *Proeryon banzensis* Kuhn; p. 156, Text-fig. 1, Pl. 13 (figs. 1-2), Pl. 14 (fig. 1), Pl. 15 (fig. 1), Pl. 16 (fig.1), **nov. syn.**
1953 – *Proeryon hartmanni* (v. Meyer) *in* Hauff; p. 27, Pl. 62 a
1969 – *Proeryon hartmanni* (v. Meyer) *in* Glaessner; p. 470, Text-fig. 274
1980 – *Proeryon hartmanni* (v. Meyer) *in* Förster; p. 76
1980 – *Proeryon banzensis* Kuhn *in* Förster; p. 76
1986 – *Proeryon macrophthalmus* (Krause) *in* Mudlos; p. 150, Text-fig. without number
1993 – *Proeryon* sp. *in* Schmidt-Kaler, Tischlinger & Werner; Text-fig. 47
1993 – *Proeryon longiceps* Beurlen *in* Jäger; Text-fig. 47
1998 – *Proeryon macrophthalmus* (Krause) *in* Böttcher; p. 88, Text-fig. 7.9
2000 – *Proeryon hartmanni* (v. Meyer) *in* Schweigert; Text-fig. 2
2001 – *Coleia* cfr. *C. banzensis* Kuhn *in* Garassino & Teruzzi; p. 190, Text-fig. 3
2001 – *Proeryon hartmanni* (v. Meyer) *in* Schweigert; Text-figs. 1-3
2001 – *Proeryon hartmanni* (v. Meyer) *in* Schweigert; Text-fig. 1
2001 – *Proeryon* sp. *in* Mäuser; p. 106, Text-fig. 4
2005 – *Proeryon hartmanni* (v. Meyer) *in* Garassino & Gironi; p. 56, Text-figs. 4-9

Stratigraphic range: Lower Jurassic (Toarcian).
Occurrence: Lombardia.
Material: Garassino & Teruzzi (2001) reported 15 specimens (MSNM from i10845 to i10850, i10853, i10854, from i10857 to i10862, i10865) from Sogno (Bergamo); Garassino & Gironi (2005) reported 21specimens (MSNM from i26209 to i 26212, from i26214 to i26218 a-b, i26220, i26222, i26223, from i26227 to i26229 a-b, from i26232 to i26236, i 26284 a-b) from Cesana Brianza-Suello (Lecco).
Note: this species is also reported from the Lower Jurassic (Toarcian) of Germany.

Pseudocoleia Garassino & Teruzzi, 1993

Type species: *Pseudocoleia mazzolenii* Garassino & Teruzzi, 1993.
Stratigraphic range: Upper Triassic (Norian).

Pseudocoleia mazzolenii Garassino & Teruzzi, 1993

1993 – *Pseudocoleia mazzolenii* Garassino & Teruzzi; p. 19, Text-figs. 35-40, Pl. 4 (figs. 3-4)
1996 – *Pseudocoleia mazzolenii* Garassino & Teruzzi *in* Garassino, Teruzzi & Dalla Vecchia; p. 41

Holotype: MSNM i12467.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia, Friuli-Venezia Giulia.
Material: Garassino & Teruzzi (1993) reported 36 specimens (the best specimens are: MSNM i12467; MSNB 7560, from 8184 to 8186, 8188) from Ponte Giurino (Bergamo); Garassino *et al.* (1996) reported six specimens (MFSN 1949, 1950, 6153 a-b, 16113 a-b, 16121, 16175) from Caprizzi (Udine).

†Family Eryonidae De Haan, 1841

Rosenfeldia Garassino, Teruzzi & Dalla Vecchia, 1996

Type species: *Rosenfeldia triasica* Garassino, Teruzzi & Dalla Vecchia, 1996.
Stratigraphic range: Upper Triassic (Norian) – Upper Jurassic (Tithonian).

Rosenfeldia triasica Garassino, Teruzzi & Dalla Vecchia, 1996

1996 – *Rosenfeldia triasica* Garassino, Teruzzi & Dalla Vecchia; p. 33, Text-figs. 6-10, 17-20

Holotype: MFSN 16178.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Friuli-Venezia Giulia.
Material: Garassino *et al.* (1996) reported 32 specimens (MFSN 1955, 16110, 16122, 16139, 16141 a-b, 16152, 16155 a-b, from 16171 to 16174 a-b, from 16176 to 16181, 16183, from 16185 to 19197) from Monte Auda and Forni di Sopra (Udine).

Family Palinuridae Latreille, 1802

Archaeopalinurus Pinna, 1974

Type species: *Archaeopalinurus levis* Pinna, 1974.
Stratigraphic range: Upper Triassic (Norian) – Lower Jurassic (Toarcian).

Archaeopalinurus levis Pinna, 1974

1974 – *Archaeopalinurus levis* Pinna; p. 29, Pl. 14 (fig. 1), Pl. 15 (fig. 3), Pl. 16 (figs. 4-5)
1976 – *Archaeopalinurus levis* Pinna *in* Pinna; p. 37
1993 – *Palinurina* cfr. *P. longipes* Münster *in* Dalla Vecchia; p. 65, Text-fig. 5
1993 – *Archaeopalinurus levis* Pinna *in* Garassino & Teruzzi; p. 17, Text-figs. 29-34, Pl. 4 (figs. 1-2)
1996 – *Archaeopalinurus levis* Pinna *in* Garassino, Teruzzi & Dalla Vecchia; p. 42, Text-figs. 21-22
2005 – *Archaeopalinurus* cfr. *A. levis* Pinna *in* Garassino & Gironi; p. 63, Text-figs. 10-11

Holotype: MSNB 3100.
Stratigraphic range: Upper Triassic (Norian).
Occurrence: Lombardia, Friuli-Venezia Giulia, Lazio.
Material: Pinna (1974) reported some specimens (MSNB) from Cene (Bergamo); Pinna (1976) reported 14 specimens (the best specimens are: MSNBS 2777, 3010) from Rest (Brescia); Garassino & Teruzzi (1993) reported eight specimens (MSNB 7569 a-b, 7567-7566, 8352; MSNM i10747, i10866, i10740) from Ponte Giurino (Bergamo); Garassino *et al.* (1996) reported 126 specimens (the best specimens are: MFSN 1392-1412, 1935-1948, 5690, 16108, 16111, 16112, 16115-16120, 16123-16138, 16143, 16144, 16147-16151, 16153, 16154, 16156-16160, 16162-16164) from Monte Auda and Rio Seazza (Udine); Garassino & Gironi (2005) reported one specimen (MSNM i26237) from Cesana Brianza-Suello (Lecco).
Note: Dalla Vecchia (1993) reported one specimen (MFSN 15099) from Filettino (Lazio). Even though the author ascribed in dubitative form the specimen to *Palinurina* cfr. *P. longipes*, it could be ascribed to *Archaeopalinurus* for some morphological characters, typical of this genus.

Justitia Holthuis, 1946

Type species: *Palinurus longimanus* H. Milne Edwards, 1837.

Stratigraphic range: middle Eocene (Lutetian) – Recent.

Justitia desmaresti (Massalongo, 1854)

1822 – *Palinurus* Weber *in* Desmarest; p. 131

1840-1850? – *Palinurus desmaresti* De Zigno; *nomen nudum*

1854 – *Palinurus* Weber *in* Catullo

1854 – *Palinurus desmaresti* Massalongo; Pl. 12

1855 – *Palinurus desmaresti* De Zigno *in* Massalongo; p. 52

1915 – *Palinurus desmaresti* De Zigno *in* Fabiani; p. 286

1975 – *Palinurus desmaresti* De Zigno *in* Secretan; p. 339, Pl. 12 (fig. 1), Pl. 13 (figs. 1-5), Pl. 14 (figs. 1-4), Pl. 15 (figs. 1-4), Pl. 16 (figs. 3-4)

2001 – *Justitia desmaresti* (Massalongo) *in* Garassino & Novati; p. 259, Text-figs. 3-7

2003 – *Justitia desmaresti* (Massalongo) *in* Garassino & De Angeli; p. 131, Text-fig. 1 A

Holotype: MSNV 91-91 bis.

Stratigraphic range: middle Eocene (Lutetian).

Occurrence: Veneto.

Material: Garassino & Novati (2001) reported 22 specimens (MSNV: 17-17 bis, CR 17, 18, M02, 19, 20, 23B, 23-90 bis, 24, 25-25 bis, 91-91 bis, 92, 93, 94, 95; MGPD: 6804Z, 7747C-7450C, 7448C-7449C; MSNM: i22867; MFB: I.G. 91130, I.G. 132590-132605; NHMW: 1853/XXVII/59-1853/XXVII/60) from Monte Bolca (Verona).

Justitia vicetina Beschin, De Angeli & Garassino, 2001

2001 – *Justitia vicetina* Beschin, De Angeli & Garassino; p. 91, Text-figs. 2-4

2001 – *Justitia vicetina* Beschin, De Angeli & Garassino *in* Garassino & Novati; p. 262

2001 – *Justitia vicetina* Beschin, De Angeli & Garassino *in* De Angeli & Beschin; p. 11, Text-fig. 7

2003 – *Justitia vicetina* Beschin, De Angeli & Garassino *in* Garassino & De Angeli; p. 131, Text-fig. 1 B

Holotype: MCZ 1543 (I.G. 284621).

Stratigraphic range: middle Eocene (Lutetian).

Occurrence: Veneto.

Material: Beschin *et al.* (2001) reported two specimens (MCZ 1543, 1544) from "Albanello" quarry (Vicenza).

Palinurus Weber, 1795

Type species: *Astacus elephas* Fabricius, 1787, by monotypy.

Stratigraphic range: Lower Cretaceous (Barremian) – Recent.

Palinurus sp.

1998b – *Palinurus* sp. *in* Bravi & Garassino; p. 110, Text-fig. 14

Stratigraphic range: Lower Cretaceous (Albian).

Occurrence: Campania.

Material: Bravi & Garassino (1998b) reported three specimens (M from 21837 to 21839) from Petina (Salerno).

Palinurus sp.

2000b – *Palinurus* sp *in* Garassino; p. 67, Text-fig. 1

Stratigraphic range: Lower Cretaceous (Barremian – Aptian).

Occurrence: Friuli Venezia-Giulia.

Material: Garassino (2000b) reported one specimen (MFSN 25000) from Torrente Cornappo (Udine).

Family Scyllaridae Latreille, 1825

Parribacus Dana, 1852

Type species: *Scyllarus antarcticus* Lund, 1793.

Stratigraphic range: middle Eocene (Lutetian) – Recent.

Parribacus cristatus Förster, 1984

1984 – *Parribacus cristatus* Förster; p. 62, Text-fig. 2

Holotype: MNHB MB.A. 88.

Stratigraphic range: middle Eocene (Lutetian).

Occurrence: Veneto.

Material: Förster (1984) reported one specimen (MNHB MB.A.88) from Monte Bolca (Verona).

Infraorder Anomura MacLeay, 1838
Family Chirostylidae Ortmann, 1892

Eumunida Smith, 1883

Type species: *Eumunida picta* Smith, 1883.

Stratigraphic range: upper Eocene (Priabonian) – Recent.

Eumunida pentacantha (Müller & Collins, 1991)

1991 – *Protomunida pentacantha* Müller & Collins; p. 57, Text-fig. 2 i, Pl. 1 (figs. 15-16)

2000 – *Eumunida pentacantha* (Müller & Collins) *in* Schweitzer & Feldmann; p. 159

2002 – *Eumunida pentacantha* (Müller & Collins) *in* De Angeli & Garassino; p. 17, Text-fig. 14, Pl. 6 (figs. 3-4)

2003 – *Eumunida pentacantha* (Müller & Collins) *in* De Angeli & Garassino; p. 99, Text-fig. 1 (11)

Holotype: MAFI EBM-1.1 (M. 91-116).

Stratigraphic range: upper Eocene (Priabonian).

Occurrence: Veneto.

Material: De Angeli & Garassino (2002) reported 18 specimens (MSNM from i25208 to i25218; MCZ from 2167 to 2173) from S. Feliciano (Vicenza).

Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Family Galatheidae Samouelle, 1819

Calteagalathea De Angeli & Garassino, 2006

Type species: *Calteagalathea friulana* De Angeli & Garassino, 2006.
Stratigraphic range: Upper Cretaceous (Maastrichtian).

Calteagalathea friulana De Angeli & Garassino, 2006

2006a – ***Calteagalathea friulana* De Angeli & Garassino**; p. 274, Text-fig. 4 (a-b)

Holotype: MFSN 19969.
Stratigraphic range: Upper Cretaceous (Maastrichtian).
Occurrence: Friuli-Venezia Giulia.
Material: De Angeli & Garassino (2006a) reported two specimens (MFSN 19965, 19969) from Val Caltea (Pordenone).

Galathea Fabricius, 1793

Type species: *Cancer strigosus* Linnaeus, 1761.
Stratigraphic range: Cretaceous – Recent.

Galathea affinis Ristori, 1886

1886 – *Galathea affinis* Ristori; p. 126, Pl. 2 (fig. 18)
1909 – *Galathea affinis* Ristori *in* Lörenthey; p. 228
1929 – *Galathea affinis* Ristori *in* Glaessner; p. 172

Holotype: unknown.
Stratigraphic range: Miocene, late Pliocene (Piacentian), upper Pleistocene (Sicilian).
Occurrence: Sicilia, Sardegna.
Material: Ristori (1886) reported one specimen from Bianchi (Palermo) (repository and catalogue number unknown); Lörenthey (1909) reported some specimens from Capo S. Marco (Oristano), housed in Lovisato's collection (repository and catalogue number unknown).

Galathea berica De Angeli & Garassino, 2002

2002 – *Galathea berica* De Angeli & Garassino; p. 7, Text-fig. 5, Pl. 1 (figs. 1-2)
2003 – *Galathea berica* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (1)

Holotype: MCZ 2186 (I.G. 296428).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported two specimens (MCZ 2186, 2187) from S. Feliciano (Vicenza).

Galathea valmaranensis De Angeli & Garassino, 2002

1994 – *Galathea weinfurteri* Bachmayer *in* Vicariotto & Beschin; p. 7, Pl. 1 (fig. 1)
1997 – *Galathea weinfurteri* Bachmayer *in* De Angeli & Messina; p. 18, Text-fig. 2
2001 – *Galathea weinfurteri* Bachmayer *in* Beschin, De Angeli & Checchi; p. 29
2001 – *Galathea weinfurteri* Bachmayer *in* De Angeli & Beschin; p. 11
2002 – *Galathea valmaranensis* De Angeli & Garassino; p. 8, Text-fig. 6, Pl. 1 (figs. 3-4), Pl. 2 (fig. 1)
2003 – *Galathea valmaranensis* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (4)
2006 – *Galathea valmaranensis* De Angeli & Garassino *in* De Angeli & Rossi; p. 90, Pl. 2 (fig. 4)

Holotype: MCZ 2228 (I.G. 296470).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported 17 specimens (MSNM from i25147 to i25159; MCZ 2228, 2230, 2231, 2233) from Valmarana (Vicenza); De Angeli & Messina (1997) and De Angeli & Rossi (2006) reported two specimens (MCZ 1550, 1551) from Perarolo (Vicenza).

Galathea cfr. *G. weinfurteri* Bachmayer, 1950

2002 – *Galathea* cfr. *G. weinfurteri* Bachmayer *in* De Angeli & Garassino; p. 10, Text-fig. 7, Pl. 2 (figs. 2-3)
2003 – *Galathea* cfr. *G. weinfurteri* Bachmayer *in* De Angeli & Garassino; p. 99, Text-fig. 1 (7)

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported six specimens (MSNM from i25236 to i25238; MCZ 2229, 2232, 2234) from Valmarana (Vicenza).

Acanthogalathea Müller & Collins, 1991

Type species: *Galathea* (*Acanthogalathea*) *parva* Müller & Collins, 1991.
Stratigraphic range: upper Eocene (Priabonian).

Acanthogalathea feldmanni De Angeli & Garassino, 2002

2002 – *Acanthogalathea feldmanni* De Angeli & Garassino; p. 12, Text-fig. 9, Pl. 3 (figs. 3-4)
2003 – *Acanthogalathea feldmanni* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (9)

Holotype: MCZ 2178.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported two specimens (MCZ 2178, 2188) from S. Feliciano (Vicenza).

Acanthogalathea parva (Müller & Collins, 1991)

1991 – *Galathea* (*Acanthogalathea*) *parva* Müller & Collins; p. 56, Text-fig. 2 h, Pl. 2 (fig. 3)
2002 – *Acanthogalathea parva* (Müller & Collins) *in* De Angeli & Garassino; p. 11, Text-fig. 8, Pl. 2 (fig. 4), Pl. 3 (figs. 1-2)
2003 – *Acanthogalathea parva* (Müller & Collins) *in* De Angeli & Garassino; p. 99, Text-fig. 1 (6)

Holotype: MAFI E.F. 31 (M. 91-106).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported eight specimens (MSNM from i25239 to i25242; MCZ from 2174 to 2177) from S. Feliciano (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Lessinigalathea De Angeli & Garassino, 2002

Type species: *Lessinigalathea regale* De Angeli & Garassino, 2002.
Stratigraphic range: lower Eocene (Ypresian).

Lessinigalathea regale De Angeli & Garassino, 2002

2000 – *Galathea* sp. *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 1 (fig. 4)
2002 – *Lessinigalathaea regale* De Angeli & Garassino; p. 13, Text-fig. 10, Pl. 4 (fig. 1)
2003 – *Lessinigalathea regale* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (2)

Holotype: MCZ 2246 (I.G. 296488).
Stratigraphic range: lower Eocene (Ypresian).
Occurrence: Veneto.
Material: Beschin *et al.* (2000) reported one specimens (MCZ 1898) from "Gecchelina" quarry of Monte di Malo (Vicenza); De Angeli & Garassino (2002) reported three specimens (MCZ 2246, 2256, 2257) from Monte Magrè of Schio (Vicenza).
Note: the correct original spelling is "*Lessinigalathea*" instead of "*Lessinigalathaea*" used incorrectly in the institution of the new genus, as misprint.

Palaeomunida Lörenthey, 1901

Type species: *Palaeomunida defecta* Lörenthey, 1901.
Stratigraphic range: Eocene – Oligocene.

Palaeomunida defecta Lörenthey, 1901

1901 – *Palaeomunida defecta* Lörenthey; p. 807, Pl. 1 (fig. 3)
1929 – *Palaeomunida defecta* Lörenthey *in* Lörenthey & Beurlen; p. 80, Pl. 3 (figs. 3-5)
1933 – *Palaeomunida defecta* Lörenthey *in* Di Salvo; p. 8, Pl. 2 (fig. 2 a-d)
1969 – *Palaeomunida defecta* Lörenthey *in* Via Boada; p. 405
1975 – *Galathea* sp. *in* Müller; p. 516, 520
1991 – *Galathea* (*Palaeomunida*) *defecta* Lörenthey *in* Müller & Collins; p. 56, Text-fig. 2 g, Pl. 1 (figs. 12-13), Pl. 2 (fig. 1)
2000 – *Palaeomunida defecta* Lörenthey *in* Schweitzer & Feldmann; p. 158
2001 – *Palaeomunida defecta* Lörenthey *in* Beschin, De Angeli & Checchi; p. 15, Pl. 1 (figs. 2-3)
2002 – *Palaeomunida defecta* Lörenthey *in* De Angeli & Garassino; p. 14, Text-fig. 11, Pl. 4 (figs. 2-5), Pl. 5 (fig. 1)
2003 – *Palaeomunida defecta* Lörenthey *in* De Angeli & Garassino; p. 99, Text-fig. 1 (3)

Holotype: MAFI.
Stratigraphic range: upper Eocene (Priabonian) – early Oligocene.
Occurrence: Veneto.
Material: Di Salvo (1933) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown); Beschin *et al.* (2001) reported 16 specimens (MCZ 2068, 2069, and from 2075 to 2088) from Castelgomberto (Vicenza); De Angeli & Garassino (2002) reported nine specimens (MSNM from i25199 to i25203, i25205, i25206; MCZ 2185, 2245) from S. Feliciano (Vicenza), 15 specimens (MSNM from i25189 to i25198, i25204, i25207; MCZ from 2247 to 2249) from "Alonte" quarry (Vicenza), 41 specimens (MSNM from i25160 to i25188 and from i25219 to i25222; MCZ from 2235 to 2240, 2241, 2242) from Valmarana (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Palaeomunida multicristata De Angeli & Garassino, 2002

2002 – *Palaeomunida multicristata* De Angeli & Garassino; p. 15, Text-fig. 15, Pl. 5 (figs. 2-4)
2003 – *Palaeomunida multicristata* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (5)

Holotype: MCZ 2184 (I.G. 296426).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported nine specimens (MCZ from 2179 to 2184 and from 2221 to 2223) from S. Feliciano (Vicenza).

Spathagalathea De Angeli & Garassino, 2002

Type species: *Spathagalathea minuta* De Angeli & Garassino, 2002.
Stratigraphic range: upper Eocene (Priabonian).

Spathagalathea minuta De Angeli & Garassino, 2002

2002 – *Spathagalathea minuta* De Angeli & Garassino; p. 17, Text-fig. 13, Pl. 6 (figs. 1-2)
2003 – *Spathagalathea minuta* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (8)

Holotype: MCZ 2192 (I.G. 296435).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported nine specimens (MCZ from 2189 to 2197, 2218) from S. Feliciano and "Alonte" quarry (Vicenza).

Indeterminates
Genus et species indeterminate

1998 – Gen. et sp. indet. *in* Garassino; p. 69, Text-fig. 4

Stratigraphic range: Lower Cretaceous (Barremian – Aptian).
Occurrence: Friuli Venezia-Giulia.
Material: Garassino (1998) reported one specimen (MFSN 21533) from Torrente Cornappo (Udine).

Family Porcellanidae Haworth, 1825

Beripetrolisthes De Angeli & Garassino, 2002

Type species: *Beripetrolisthes mulleri* De Angeli & Garassino, 2002.
Stratigraphic range: upper Eocene (Priabonian).

Beripetrolisthes mulleri De Angeli & Garassino, 2002

1991 – Porcellanidae sp. B *in* Müller & Collins; p. 60, Text-fig. 2 n, Pl. 2 (fig. 2)
2002 – *Beripetrolisthes mulleri* De Angeli & Garassino; p. 19, Text-fig. 15, Pl. 7 (figs. 1-2)
2003 – *Beripetrolisthes mulleri* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (12)

Holotype: MCZ 2216 (I.G. 296458).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported seven specimens (MCZ from 2205 to 2208, 2216, 2217) from S. Feliciano (Vicenza).

Eopetrolisthes De Angeli & Garassino, 2002

Type species: *Petrolisthes*? *striatissimus* Müller & Collins, 1991.
Stratigraphic range: upper Eocene (Priabonian).

Eopetrolisthes striatissimus (Müller & Collins, 1991)

1991 – *Petrolisthes*? *striatissimus* Müller & Collins; p. 59, Text-fig. 2 1, Pl. 2 (fig. 8)
2001 – *Petrolisthes*? *striatissimus* Müller & Collins *in* Beschin, De Angeli & Checchi; p. 17
2002 – *Eopetrolisthes striatissimus* (Müller & Collins) *in* De Angeli & Garassino; p. 20, Text-fig. 16, Pl. 7 (figs. 3-4)
2003 – *Eopetrolisthes striatissimus* (Müller & Collins) *in* De Angeli & Garassino; p. 99, Text-fig. 1 (13)

Holotype: MAFI EGA-5.1 (M.91-123).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported 20 specimens (MSNM from i25223 to i25235; MCZ from 2198 to 2203, 2254) from S. Feliciano (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Lobipetrolisthes De Angeli & Garassino, 2002

Type species: *Lobipetrolisthes blowi* De Angeli & Garassino, 2002.
Stratigraphic range: upper Eocene (Priabonian).

Lobipetrolisthes blowi De Angeli & Garassino, 2002

2002 – *Lobipetrolisthes blowi* De Angeli & Garassino; p. 21, Text-fig. 17, Pl. 8 (figs. 1-3)
2003 – *Lobipetrolisthes blowi* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (10)

Holotype: MCZ 2226 (I.G. 296468).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported 15 specimens (MSNM from i25243 to i25249; MCZ 2219, 2220, from 2224 to 2227, 2252, 2253) from S. Feliciano (Vicenza).

Longoporcellana Müller & Collins, 1991

Type species: *Longoporcellana denticulata* Müller & Collins, 1991.
Stratigraphic range: upper Eocene (Priabonian).

Longoporcellana lobata De Angeli & Garassino, 2002

2002 – *Longoporcellana lobata* De Angeli & Garassino; p. 22, Text-fig. 18, Pl. 8 (fig. 4), Pl. 9 (fig. 1)
2003 – *Longoporcellana lobata* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (16)

Holotype: MCZ 2250 (I.G. 296492).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported six specimens (MCZ from 2212 to 2215, 2250, 2251) from S. Feliciano (Vicenza).

Petrolisthes Stimpson, 1858

Type species: *Porcellana violacea* Guérin-Méneville *in* Duperry, 1831, by monotypy.
Stratigraphic range: Eocene – Recent.

Petrolisthes bittneri De Angeli & Garassino, 2002

2002 – *Petrolisthes bittneri* De Angeli & Garassino; p. 23, Text-fig. 19, Pl. 9 (fig. 2)
2003 – *Petrolisthes bittneri* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (14)

Holotype: MCZ 2243 (I.G. 296485).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported two specimens (MCZ 2243, 2255) from S. Feliciano (Vicenza).

Petrolisthes vicetinus Beschin, De Angeli & Checchi, 2001

2001 – *Petrolisthes vicetinus* Beschin, De Angeli & Checchi; p. 16, Text-fig. 2, Pl. 1 (figs. 1-4)
2002 – *Petrolisthes vicetinus* Beschin, De Angeli & Checchi *in* De Angeli & Garassino; p. 24, Text-fig. 20, Pl. 9 (fig. 3)
2003 – *Petrolisthes vicetinus* Beschin, De Angeli & Checchi *in* De Angeli & Garassino; p. 99, Text-fig. 1 (15)

Holotype: MCZ 2070 (I.G. 286425).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported four specimens (MCZ 2070, 2093, 2094, 2120) from Castelgomberto (Vicenza); De Angeli & Garassino (2002)

reported one specimen (MCZ 2244) from Creazzo (Vicenza).

Pisidia Leach, 1820

Type species: *Cancer longicornis* Linnaeus, 1767.
Stratigraphic range: Eocene – Recent.

Pisidia dorsosinuosa De Angeli & Garassino, 2002

2002 – *Pisidia dorsosinuosa* De Angeli & Garassino; p. 24, Text-fig. 21, Pl. 9 (fig. 4)
2003 – *Pisidia dorsosinuosa* De Angeli & Garassino *in* De Angeli & Garassino; p. 99, Text-fig. 1 (17)

Holotype: MCZ 2210 (I.G. 296452).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2002) reported three specimens (MCZ from 2209 to 2211) from S. Feliciano (Vicenza).

Superfamily Hippoidea Latreille, 1825
Family Albuneidae Stimpson, 1858

Albunea Weber, 1795

Type species: *Albunea symmysta* Linnaeus, 1758.
Stratigraphic range: Eocene – Recent.

Albunea cuisiana Beschin & De Angeli, 1984

1984 – *Albunea cuisiana* Beschin & De Angeli; p. 97, Pl. 1 (figs. 1, 1 a), Pl. 2 (figs. 1, 1 a-b)
1998 – *Albunea cuisiana* Beschin & De Angeli *in* De Angeli; p. 17
2001 – *Albunea cuisiana* Beschin & De Angeli *in* De Angeli & Beschin; p. 12, Text-fig. 9
2005 – *Albunea cuisiana* Beschin & De Angeli *in* De Angeli, Beschin & Checchi; p. 75, Pl. 1 (fig. 5)

Holotype: MSNVE 10439.
Stratigraphic range: lower Eocene (Ypresian).
Occurrence: Veneto.
Material: Beschin & De Angeli (1984) reported three specimens (MCZ 1332, 1532; MSNVE 10439) from "Lovara" and "Boschetto" quarries of Chiampo (Vicenza).

Italialbunea Boyko, 2002

Type species: *Albunea lutetiana* Beschin & De Angeli, 1984.
Stratigraphic range: Eocene.

Italialbunea lutetiana (Beschin & De Angeli, 1984)

1984 – *Albunea lutetiana* Beschin & De Angeli; p. 99, Pl. 1 (figs. 2, 2 a), Pl. 2 (figs. 2-3, 3 a)
1998 – *Albunea lutetiana* Beschin & De Angeli *in* De Angeli; p. 19, Pl. 1 (figs. 1-4)
2001 – *Albunea lutetiana* Beschin & De Angeli *in* De Angeli & Beschin; p. 12
2002 – *Italialbunea lutetiana* (Beschin & De Angeli) *in* Boyko; p. 221, Text-fig. 72
2004 – *Italialbunea lutetiana* (Beschin & De Angeli) *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Italialbunea lutetiana* (Beschin & De Angeli) *in* De Angeli, Beschin & Checchi; p. 75, Pl. 1 (figs. 1-3, 3 a)

Holotype: MSNVE 10440.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin & De Angeli (1984) reported one specimen (MSNVE 10440) from "Main" quarry of Arzignano (Vicenza); De Angeli (1998) and De Angeli *et al.* (2005) reported six specimens (MCZ 1159, 1177, 1375, 1533, 1534, 2403, 1276) from "Main" quarry of Arzignano and "Albanello" quarry of Nogarole Vicentino, and one specimen (MCZ 1545) from "Alonte" quarry (Vicenza).

Stemonopa Efford & Haig, 1968

Type species: *Stemonopa insignis* Efford & Haig, 1968.
Stratigraphic range: Eocene – Recent.

Stemonopa prisca De Angeli, Beschin & Checchi, 2005

2005 – *Stemonopa prisca* De Angeli, Beschin & Checchi; p.75, Text-fig. 2, Pl. 1 (fig. 4 a-b)

Holotype: MCZ 2404 (I.G. 305111).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: De Angeli *et al.* (2005) reported one specimen (MCZ 2404) from "Main" quarry of Arzignano (Vicenza).

Zygopa Holthuis, 1961

Type species: *Zygopa michaelis* Holthuis, 1961.
Stratigraphic range: Oligocene – Recent.

Zygopa galantensis (De Angeli & Marangon, 2001)

2001 – *Paralbunea galantensis* De Angeli & Marangon; p. 102, Text-figs. 3-4
2003a – *Zygopa galantensis* (De Angeli & Marangon) *in* De Angeli & Marangon; p. 103, Text-fig. 1 (4 a-b)
2003b – *Zygopa galantensis* (De Angeli & Marangon) *in* De Angeli & Marangon; p. 187, Text-fig. 2 a-b
2004 – *Harryhausenia galantensis* (De Angeli & Marangon) *in* Boyko; p. 935, Text-fig. 1 c
2005 – *Zygopa galantensis* (De Angeli & Marangon) *in* De Angeli, Beschin & Checchi; p. 89

Holotype: MCZ 2061 (I.G. 286339).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte.
Material: De Angeli & Marangon (2001) reported one specimen (MCZ 2061) from Galanti (Alessandria).
Note: De Angeli & Marangon (2003 a, b) included *Paralbunea galantensis* in *Zygopa*; even though Boyko (2004) suggested to include this species in the new genus *Harryhausenia*, De Angeli & Marangon

(2003a, b) pointed out that the morphological characters of the fossil species are the same of the Recent *Zygopa*.

Superfamily Paguroidea Latreille, 1802
Family Diogenidae Ortmann, 1892

Calcinus Dana, 1851

Type species: *Calcinus tibicen* (Herbst, 1791).
Stratigraphic range: Eocene – Recent.

Calcinus agnoensis Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Calcinus agnoensis* Beschin, De Angeli, Checchi & Zarantonello; p. 12, Text-fig. 8, Pl. 2 (figs. 5 a-c, 6)

Holotype: MCZ 2356 (I.G. 296575).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported six specimens (MCZ 2284, 2339, 2342, 2355, 2356, 2357) from Grola di Cornedo Vicentino (Vicenza).

Calcinus sp.

1891b – *Calcinus* sp. *in* Ristori; p. 24

Stratigraphic range: Pliocene.
Occurrence: Lazio.
Material: Ristori (1891b) reported two specimens from Monte Mario (Roma), housed in Zuccari's collection (repository and catalogue number unknown).

Dardanus Paulson, 1875

Type species: *Dardanus hellerii* Paulson, 1875.
Stratigraphic range: Eocene – Recent.

Dardanus mediterraneus (Lörenthey, 1909)

1909 – *Pagurus mediterraneus* Lörenthey; p. 226, Pl. 2 (fig. 5 a-b)
1929 – *Pagurus mediterraneus* Lörenthey *in* Glaessner; p. 288
2002 – *Dardanus mediterraneus* (Lörenthey) *in* Beschin, Busulini, De Angeli & Tessier; p. 12

Holotype: unknown.
Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported some specimens from Monte della Pace (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Dardanus sp.

2000 – *Dardanus* sp. *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 1 (fig. 3)
2001 – *Dardanus* sp. *in* De Angeli & Beschin; p. 13

Stratigraphic range: lower Eocene (Ypresian).
Occurrence: Veneto.
Material: Beschin *et al.* (2000) reported one specimen (MCZ 2013) from "Gecchelina" quarry of Monte di Malo (Vicenza).

Dardanus sp.

2005 – *Dardanus* sp. *in* Beschin, De Angeli, Checchi & Zarantonello; p. 14, Text-fig. 10, Pl. 2 (fig. 3)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported one specimen (MCZ 2384) from Grola di Cornedo Vicentino (Vicenza).

Diogenes Dana 1851

Type species: *Pagurus miles* Fabricius, 1787.
Stratigraphic range: Eocene – Recent.

Diogenes sp.

2000 – *Diogenes* sp. *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 1 (fig. 2)
2001 – *Diogenes* sp. *in* De Angeli & Beschin; p. 13

Stratigraphic range: lower Eocene (Ypresian).
Occurrence: Veneto.
Material: Beschin *et al.* (2000) reported one specimen (MCZ 1920) from "Gecchelina" quarry of Monte di Malo (Vicenza).

Eocalcinus Via Boada, 1959

Type species: *Eocalcinus eocenicus* Via Boada, 1959.
Stratigraphic range: Eocene.

Eocalcinus cavus Beschin, Busulini, De Angeli & Tessier, 2002

1997 – *Petrochirus priscus in* Vicariotto, p. 27, Text-fig. 1 a-d
2000 – *Pagurus* sp. *in* De Angeli & Franchi; p. 20
2001 – *Pagurus* sp. *in* De Angeli & Beschin; p. 13
2002 – *Eocalcinus cavus* Beschin, Busulini, De Angeli & Tessier; p. 10, Text-fig 5, Pl. 1 (fig. 5 a-b), Pl. 2 (fig. 1)
2004 – *Eocalcinus cavus* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Eocalcinus cavus* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 12, Pl. 2 (fig. 2)

Holotype: MCZ 2263 (I.G. 296391).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Vicariotto (1997) reported one specimen (MCZ 1574) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2002) reported two specimens (MCZ 2263, 2264) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2383) from Grola di Cornedo Vicentino (Vicenza).

Eocalcinus eocenicus Via Boada, 1959

1959 – *Eocalcinus eocenicus* Via Boada; p. 32, Text-fig. 5
1969 – *Eocalcinus eocenicus* Via Boada *in* Via Boada; p. 93, Text-fig. 9, Pl. 3 (figs. 1-3)
1989 – *Eocalcinus eocenicus* Via Boada *in* Solè & Via Boada; p. 28
1994 – *Eocalcinus eocenicus* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 164, Pl. 1 (fig. 2)
2004 – *Eocalcinus eocenicus* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Eocalcinus eocenicus* Via Boada *in* Beschin, De Angeli, Checchi & Zarantonello; p. 13

Holotype: MMGB 6649.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported three specimens (MCZ 1436, 1437, 1438) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).
Note: this species is also reported from the Eocene of Spain.

Paguristes Dana, 1851

Type species: *Paguristes hirtus* Stimpson, 1858.
Stratigraphic range: Cretaceous – Recent.

Paguristes lineatuberculatus Beschin, De Angeli, Checchi & Mietto, 2006

2006 – *Paguristes lineatuberculatus* Beschin, De Angeli, Checchi & Mietto; p. 102, Text-fig. 5, Pl. 1 (fig. 8 a-b)

Holotype: MCZ 2432.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (2006) reported one specimen (MCZ 2432) from Grotta della Poscola (Vicenza).

Paguristes prealpinus Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Paguristes prealpinus* Beschin, De Angeli, Checchi & Zarantonello; p. 13, Text-fig. 9, Pl. 2 (fig. 4 a-b)

Holotype: MCZ 2340 (I.G. 296559).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported four specimens (MCZ 2330, 2331, 2340, 2358) from Grola di Cornedo Vicentino (Vicenza).

Petrochirus Stimpson, 1859

Type species: *Pagurus granulatus* Olivieri, 1811.
Stratigraphic range: Eocene – Recent.

Petrochirus mezi (Lörenthey, 1909)

1909 – ***Pagurus mezi* Lörenthey**; p. 113, Pl. 2 (fig. 4 a-b)
1994 – *Pagurus* cfr. *mezi* Lörenthey *in* Beschin, Busulini, De Angeli & Tessier; p. 163, Pl. 1 (fig. 1 a-c)
2001 – *Pagurus* cfr. *mezi* Lörenthey *in* De Angeli & Beschin; p. 13
2002 – *Petrochirus mezi* (Lörenthey) *in* Beschin, Busulini, De Angeli & Tessier; p. 11, Text-fig. 6, Pl. 1 (fig. 6 a-b)
2004 – *Pagurus mezi* Lörenthey *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2006 – *Petrochirus mezi* (Lörenthey) *in* Beschin, De Angeli, Checchi & Mietto; p. 99, Pl. 1 (fig. 9 a-b)

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian–Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported one specimen (MCZ 1313) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2002) reported one specimen (MCZ 2265) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2006) reported one specimen (MCZ 2430) from Rio Poscola (Vicenza).
Note: this species is also reported from the middle Eocene (Lutetian) of Egypt.

Petrochirus poscolensis Beschin, De Angeli, Checchi & Mietto, 2006

2006 – *Petrochirus poscolensis* Beschin, De Angeli, Checchi & Mietto; p. 100, Text-fig. 4, Pl. 1 (fig. 7 a-c)

Holotype: MCZ 2431.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (2006) reported one specimen (MCZ 2431) from Rio Poscola (Vicenza).

Petrochirus sp.

1995 – *Petrochirus* sp. *in* De Angeli; p. 11, Text-fig. 2 (2 a-b), Pl. 1 (fig. 4 a-c)
2001 – *Petrochirus* sp. *in* De Angeli & Beschin; p. 13

Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli (1995) reported two specimens (MCZ 1491, 1492) from "Fontanella" di Grancona (Vicenza).

Family Paguridae Latreille, 1802

Anapagurus Henderson, 1888

Type species: *Pagurus laevis* Bell, 1845.
Stratigraphic range: Pliocene – Recent.

Anapagurus sp.

2004a – *Anapagurus* sp. *in* Garassino & De Angeli; p. 37, Text-fig. 3 (9)

Stratigraphic range: Pleistocene.
Occurrence: Emilia Romagna.
Material: Garassino & De Angeli (2004a) reported one specimen (MG 0635) from Fiume Arda (Piacenza).

Pagurus Fabricius, 1775

Type species: *Cancer bernhardus* Linnaeus, 1758.

Stratigraphic range: Cretaceous – Recent.

Pagurus arrosor (Herbst, 1794)

1794 – *Cancer arrosor* Herbst; p. 170, Pl. 43 (fig. 1)
1891b – *Pagurus striatus* Latreille *in* Ristori; p. 23
1929 – *Pagurus arrosor* (Herbst) *in* Glaessner; p. 287

Holotype: unknown.
Stratigraphic range: Pliocene.
Occurrence: Lazio.
Material: Ristori (1891b) reported some specimens from Monte Mario (Roma), housed in Rigacci's and Clerici's collections (repository and catalogue number unknown).

Pagurus manzonii (Ristori, 1888)

1888 – *Xantho? manzonii* Ristori; p. 213, Pl. 4 (figs. 1-4)
1895 – *Xantho? manzonii* Ristori *in* Crema; p. 677
1896 – *Pagurus manzonii* (Ristori) *in* Ristori; p. 511, Pl. 12 (figs. 6-8)
1909 – *Pagurus manzonii* (Ristori) *in* Lörenthey; p. 223
1929 – *Pagurus manzonii* (Ristori) *in* Glaessner; p. 287
1950 – *Pagurus manzoni* (Ristori) *in* Comaschi Caria; p. 326
1956 – *Pagurus manzoni* (Ristori) *in* Comaschi Caria; p. 288
1981 – *Pagurus manzonii* (Ristori) *in* Delle Cave; p. 44

Syntypes: IGF 851E.
Stratigraphic range: Miocene.
Occurrence: Emilia Romagna, Sardegna.
Material: Ristori (1888) reported portions of some specimens (IGF) from S. Maria Vigiliana (Bologna), housed in Manzoni's collection, and from Monte S. Michele and Tramezzano (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown); Crema (1895) reported many specimens from Torino (repository and catalogue number unknown); Ristori (1896) reported some specimens from Tramezzario di S. Avendrace and Monte della Pace (Cagliari) (repository and catalogue number unknown); Lörenthey (1909) reported one specimen from S. Avendrace (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Pagurus squamosus Ristori, 1886

1886 – *Pagurus squamosus* Ristori; p. 125, Pl. 3 (figs. 3-5)
1929 – *Pagurus*? (*Calcinus*?) *squamosus* Ristori *in* Glaessner; p. 288
1981 – *Pagurus squamosus* Ristori *in* Delle Cave; p. 44

Holotype: IGF 860E.
Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1886) reported one specimen (IGF 860E) from Sarteano (Siena).

Pagurus substriatus A. Milne Edwards, 1861

1846 – *Pagurus striatus* Latreille *in* E. Sismonda; p. 70, Pl. 3 (fig. 8)
1861 – *Pagurus substriatus* A. Milne Edwards *in* E. Sismonda; p. 20
1886 – *Pagurus substriatus* A. Milne Edwards *in* Ristori; p. 124, Pl. 3 (figs. 14-15)
1929 – *Pagurus substriatus* A. Milne Edwards *in* Glaessner; p. 288

Holotype: lost.
Stratigraphic range: Pliocene.
Occurrence: Piemonte, Toscana, Sardegna.
Material: A. Milne Edwards (1861) reported one specimen from Asti, today lost; E. Sismonda (1846) reported one specimen from Asti, today lost; E. Sismonda (1861) reported this species without pointing out number of specimens and repository; Ristori (1886) reported two specimens from Volterra (Firenze), today lost.
Note: E. Sismonda (1846) reported one specimen ascribing it to *Pagurus striatus*, later E. Sismonda (1861) ascribed the same specimen to *Pagurus substriatus*.

Pagurus cfr. *P. substriatus* A. Milne Edwards, 1861

1896 – *Pagurus* cfr. *substriatus* A. Milne Edwards *in* Ristori; p. 510, Pl. 12 (fig. 5)
1909 – *Pagurus* cfr. *substriatus* A. Milne Edwards *in* Lörenthey; p. 225
1929 – *Pagurus* cfr. *substriatus* A. Milne Edwards *in* Glaessner; p. 288
1950 – *Pagurus* cfr. *substriatus* A. Milne Edwards *in* Comaschi Caria; p. 326
1956 – *Pagurus* cfr. *substriatus* A. Milne Edwards *in* Comaschi Caria; p. 288

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Ristori (1896) reported one specimen from Capo S. Elia (Cagliari) (repository and catalogue number unknown); Lörenthey (1909) reported two specimens from Capo S. Elia and Monte S. Michele (Cagliari) (repository and catalogue number unknown).

Pagurus sp.

1889 – *Pagurus* sp. *in* Ristori; p. 408, Pl. 15 (figs. 14-16)
1929 – *Pagurus* sp. *in* Glaessner; p. 289
1974 – *Pagurus* sp. *in* Mastrorilli; p. 4

Stratigraphic range: Miocene.
Occurrence: Liguria.
Material: Ristori (1889) reported some specimens from Dego and Sassello (Savona), housed in don Perrando's collection, today lost and in Michelotti's collection (repository and catalogue number unknown).

Pagurus sp.

1902 – *Pagurus* sp. *in* Lovisato; p. 8
1950 – *Pagurus* sp. *in* Comaschi Caria; p. 326
1956 – *Pagurus* sp. *in* Comaschi Caria; p. 288

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lovisato (1902) reported some specimens from S. Bartolomeo (Cagliari) (repository and catalogue number unknown).

Pagurus sp.

1914 – *Pagurus* sp. *in* M. Gemmellaro; p. 92

Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.

Material: M. Gemmellaro (1914) reported some specimens from Ficarazzi (Palermo) (MGUP, catalogue number unknown).

Pagurus sp.

2004a – *Pagurus* sp. *in* Garassino & De Angeli; p. 37, Text-fig. 3 (4-6)

Stratigraphic range: Pleistocene.
Occurrence: Emilia Romagna.
Material: Garassino & De Angeli (2004a) reported three specimens (MG from 0632 to 0634) from Fiume Arda (Piacenza).

Pagurus sp.

2004 – *Pagurus* sp. *in* Garassino, De Angeli, Gallo & Pasini; p. 256, Text-fig. 2 a-c

Stratigraphic range: Pliocene.
Occurrence: Piemonte.
Material: Garassino *et al.* (2004) reported four specimens (PU from 41144 to 41147) from Masserano and Cossato (Biella).

Indeterminate
Genus indeterminate

1995 – Genus indet. *in* Collins & Dieni; p. 69, Text-fig. 2 (3, 5, 6).

Stratigraphic range: Upper Cretaceous (Cenomanian).
Occurrence: Friuli-Venezia Giulia.
Material: Collins & Dieni (1995) reported one specimen (MGPD 242) from Col dei Schiosi (Pordenone).

Infraorder Brachyura Latreille, 1802
Section Podotremata Guinot, 1977
Subsection Dromiacea De Haan, 1833
Superfamily Homolodromioidea Alcock, 1899
†Family Prosopidae v. Meyer, 1860

Pithonoton v. Meyer, 1842

Type species: *Prosopon marginatum* v. Meyer, 1842.
Stratigraphic range: Jurassic – Paleocene.

Pithonoton bidentatum (Reuss, 1858)

1858 – *Goniodromites bidentatus* Reuss; p. 12
1869 – *Prosopon etalloni* G. G. Gemmellaro; p. 12, Pl. 2 (figs. 50-51), **nov. syn.**
1929 – *Pithonoton* (*Goniodromites*) *etalloni* (G. G. Gemmellaro) *in* Glaessner; p. 327
1988 – *Pithonoton bidentatum* (Reuss) *in* Wehner; p. 87, Pl. 6 (Figs. 4-6)
1998 – *Pithonoton bidentatum* (Reuss) *in* Müller; p. 17

Holotype: lost.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: G. G. Gemmellaro (1869) reported some specimens from Castello di Termini (Palermo), housed in Battaglia's collection (MGUP, catalogue number unknown).
Note: this species is also reported from the Jurassic of Germany and Austria.

Pithonoton grande (v. Meyer, 1860)

1860 – *Prosopon grande* v. Meyer; p. 202, Pl. 23 (figs. 10-13)
1869 – *Prosopon polyphemi* G. G. Gemmellaro; p. 17, Pl. 2 (fig. 59), **nov. syn.**
1925 – *Pithonoton polyphemi* (G. G. Gemmellaro) *in* Van Straelen; p. 367
1929 – *Pithonoton polyphemi* (G. G. Gemmellaro) *in* Glaessner; p. 323
1988 – *Pithonoton grande* (v. Meyer) *in* Wehner; p. 91, Pl. 7 (figs. 1-2)
1998 – *Pithonoton grande* (v. Meyer) *in* Müller; p. 17

Lectotype: BSPG 1881 IX 678.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: G. G. Gemmellaro (1869) reported one specimen from Villabate (Palermo) (MGUP, catalogue number unknown).
Note: this species is also reported from the Jurassic of Austria.

Pithonoton marginatum (v. Meyer, 1842)

1842 – *Prosopon marginatum* v. Meyer; p. 72, Pl. 15 (fig. 3)
1869 – *Prosopon marginatum* v. Meyer *in* G. G. Gemmellaro; p. 11, Pl. 2 (figs. 48-49)
1929 – *Pithonoton marginatum* (v. Meyer) *in* Glaessner; p. 322
1988 – *Pithonoton marginatum* (v. Meyer) *in* Wehner; p. 79, Pl. 5 (fig. 8), Pl. 6 (fig. 1)
1998 – *Pithonoton marginatum* (v. Meyer) *in* Müller; p. 18
2000 – *Pithonoton marginatum* (v. Meyer) *in* Müller, Krobicki & Wehner; p. 54, Text-figs. 12, 17 K, L, 18 A-E
2006a – *Pithonoton marginatum* (v. Meyer) *in* De Angeli & Garassino; p. 277, Text-fig. 5

Neotype: BSPG 1881 IX 681.
Stratigraphic range: Upper Jurassic (Oxfordian – Tithonian).
Occurrence: Friuli-Venezia Giulia, Sicilia.
Material: G. G. Gemmellaro (1869) reported two specimens from Castello di Termini and Villabate (Palermo), housed in Battaglia's collection (MGUP, catalogue number unknown); De Angeli & Garassino (2006a) reported one specimen (MFSN 15763) from Altopiano Prat (Udine).
Note: this species is also reported from the Jurassic of Germany and Austria.

Indeterminate family

Oxythyreus Reuss, 1858

Type species: *Oxythyreus gibbus* Reuss, 1858.
Stratigraphic range: Upper Jurassic (Tithonian).

Oxythyreus gibbus Reuss, 1858

1858 – *Oxythyreus gibbus* Reuss; p. 12

1859 – *Oxythyreus gibbus* Reuss *in* Reuss; p. 75, Pl. 24 (figs. 8-9)
1860 – *Oxythyreus gibbus* Reuss *in* v. Meyer; p. 218
1869 – *Oxythyreus gibbus* Reuss *in* G. G. Gemmellaro; p. 18
1889 – *Oxythyreus gibbus* Reuss *in* Moericke; p. 56
1895 – *Oxythyreus gibbus* Reuss *in* Remeš; p. 201, Pl. 1 (fig. 5)
1905 – *Oxythyreus gibbus* Reuss *in* Remeš; p. 35
1929 – *Oxythyreus gibbus* Reuss *in* Glaessner; p. 285
1969 – *Oxythyreus gibbus* Reuss *in* Glaessner; p. 489, Text-fig. 301 (2)

Holotype: unknown.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: G. G. Gemmellaro (1869) reported one specimen from Misilmeri (Palermo) (MGUP, catalogue number unknown).
Note: this species is also reported from the Upper Jurassic (Tithonian) of Moravia.

Superfamily Dromioidea De Haan, 1833
Family Dromiidae De Haan, 1833

Dromia Weber, 1795

Type species: *Cancer personatus* Linnaeus, 1758.
Stratigraphic range: Eocene – Recent.

Dromia vulgaris H. Milne Edwards, 1837

1837 – *Dromia vulgaris* H. Milne Edwards; p. 173
1885 – *Dromia vulgaris* H. Milne Edwards *in* Carus; p. 498
1914 – *Dromia vulgaris* H. Milne Edwards *in* M. Gemmellaro; p. 77, Pl. 1 (fig. 1)
1929 – *Dromia vulgaris* H. Milne Edwards *in* Glaessner; p. 139

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported one specimen from Monte Pellegrino (Palermo) (MGUP, catalogue number unknown).

?*Dromia* sp.

1933 – ?*Dromia* sp. *in* Di Salvo; p. 11, Pl. 2 (fig. 7 a-b)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported one specimen from La Pietra Lunga (Palermo) (MGUP, catalogue number unknown).

Noetlingia Beurlen, 1928

Type species: *Dromia claudiopolitana* Bittner, 1893.
Stratigraphic range: Eocene – Oligocene.

Noetlingia claudiopolitana (Bittner, 1893)

1893 – *Dromia claudiopolitana* Bittner; p. 21, Pl. 2 (fig. 5)
1928 – *Noetlingia claudiopolitana* (Bittner) *in* Beurlen; p. 166
1929 – *Noetlingia claudiopolitana* (Bittner) *in* Glaessner; p. 274
1929 – *Noetlingia claudiopolitana* (Bittner) *in* Lörenthey & Beurlen; p. 99, Pl. 4 (figs. 8-9)
1994 – *Noetlingia claudiopolitana* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 166, Pl. 1 (fig. 4)
2001 – *Noetlingia claudiopolitana* (Bittner) *in* De Angeli & Beschin; p. 14

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported two specimens (MCZ 1212, 1252) from "Boschetto" quarry of Nogarole Vicentino and "Lovara" quarry of Chiampo (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Noetlingia veronensis (Bittner, 1886)

1886 – *Dromia veronensis* Bittner; p. 46, Pl. 1 (fig. 2)
1901 – *Dromia veronensis* Bittner *in* Oppenheim; p. 284
1915 – *Dromia veronensis* Bittner *in* Fabiani; p. 285
1928 – *Noetlingia veronensis* (Bittner) *in* Beurlen; p. 166
1929 – *Noetlingia veronensis* (Bittner) in Glaessner; p. 274

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Bittner (1883) reported one specimen from San Giovanni in Valle (Verona) (repository and catalogue number unknown).

Family Dynomenidae Ortmann, 1892

Basinotopus McCoy, 1849

Type species: *Inachus lamarckii* Desmarest, 1822.
Stratigraphic range: Eocene.

Basinotopus lamarcki (Desmarest, 1822)

1822 – *Inachus Lamarcki* Desmarest; p. 116, Pl. 9 (figs. 15-16)
1849 – *Basinotopus Lamarckii* (Desmarest) *in* McCoy; p. 168
1854 – *Basinotopus Lamarckii* (Desmarest) *in* McCoy; p. 123
1858 – *Dromilites Lamarckii* (Desmarest) *in* Bell; p. 29, Pl. 5 (figs. 1-9)
1898 – *Dromilites Lamarcki* (Desmarest) *in* Carter; p. 19
1928 – *Dromilites lamarcki* (Desmarest) *in* Beurlen; p. 163
1933 – *Dromia Fabr.*? (sic!) (Desmarest) *in* Di Salvo; p. 11, Pl. 2 (fig. 7)
1983 – *Dromilites lamarcki* (Desmarest) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 57, Pl. 1 (fig. 2)
2001 – *Dromilites lamarcki* (Desmarest) *in* De Angeli & Beschin; p. 14
2002 – *Basinotopus lamarckii* (Desmarest) *in* Collins; p. 83
2004 – *Basinotopus lamarcki* (Desmarest) *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Basinotopus lamarcki* (Desmarest) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 15, Pl. 2 (fig. 9)

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto, Sicilia.

Material: Di Salvo (1933) reported one specimen from La Pietra Lunga (Palermo) (catalogue number unknown); Busulini *et al.* (1983) reported one specimen (*11) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2338) from Grola di Cornedo Vicentino (Vicenza).

Note: this species is also reported from the lower Eocene (Ypresian) of Great Britain.

Cyamocarcinus Bittner, 1883

Type species: *Cyamocarcinus angustifrons* Bittner, 1883.

Stratigraphic range: lower/upper Eocene.

Cyamocarcinus angustifrons Bittner, 1883

1883 – *Cyamocarcinus angustifrons* Bittner; p. 310, Pl. 1 (fig. 8)
1894 – *Cyamocarcinus angustifrons* Bittner *in* De Gregorio; p. 9, Pl. 1 (fig. 2)
1897 – *Cyamocarcinus angustifrons* Bittner *in* Lörenthey; p. 155
1898 – *Cyamocarcinus angustifrons* Bittner *in* Lörenthey; p. 53, Pl. 3 (fig. 2)
1899 – *Cyamocarcinus budensis* Oppenheim; p. 58; **nov. syn.**
1905 – *Cyamocarcinus angustifrons* Bittner *in* Checchia-Rispoli; p. 314, Pl. 1 (figs. 5-8)
1910a – *Cyamocarcinus angustifrons* Bittner *in* Fabiani; p. 26
1929 – *Cyamocarcinus angustifrons* Bittner *in* Glaessner; p. 131
1929 – *Cyamocarcinus angustifrons* Bittner *in* Lörenthey & Beurlen; p. 219, Pl. 10 (figs. 2, 6)
1933 – *Cyamocarcinus angustifrons* Bittner *in* Di Salvo; p. 27
1969 – *Cyamocarcinus angustifrons* Bittner *in* Via Boada; p. 372
1975 – *Cyamocarcinus angustifrons* Bittner *in* Müller; p. 516, 520
1991 – *Cyamocarcinus angustifrons* Bittner *in* Müller & Collins; p. 64, Pl. 3 (figs. 9-10)
2000 – *Cyamocarcinus angustifrons* Bittner *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 2 (fig. 1 a-b)
2001 – *Cyamocarcinus angustifrons* Bittner *in* De Angeli & Beschin; p. 14

Holotype: unkonwn.
Stratigraphic range: lower/upper Eocene (Ypresian – Priabonian).
Occurrence: Veneto, Sicilia.
Material: Bittner (1883) reported one specimen from Monte Magrè di Schio (Vicenza) (repository and catalogue number unknown); De Gregorio (1894) reported one specimen from Monte Postale di Bolca (Verona) (repository and catalogue number unknown); Checchia-Rispoli (1905) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown); Di Salvo (1933) reported 30 specimens from Balzo del Gatto, La Pietra Lunga, and Bichinello (Palermo) (MGUP, catalogue number unknown); Beschin *et al.* (2000) reported one specimen (MCZ 1678) from "Gecchelina" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the upper Eocene of Hungary.

Cyclothyreus Remeš, 1895

Type species: *Cyclothyreus strambergensis* Remeš, 1895.

Stratigraphic range: Upper Jurassic (Tithonian).

Cyclothyreus oxythyreiforme (G. G. Gemmellaro, 1869)

1869 – *Prosopon oxythyreiforme* G. G. Gemmellaro; p. 15, Pl. 2 (fig. 58), Pl. 3 (fig. 1)
1889 – *Prosopon oxythyreiforme* G. G. Gemmellaro *in* Moericke; p. 57, Pl. 6 (fig. 10)
1895 – *Prosopon oxythyreiforme* G. G. Gemmellaro *in* Remeš; p. 202, Pl. 2 (fig. 9)
1897 – *Prosopon* cfr. *P. oxythyreiforme* G. G. Gemmellaro *in* Roman; p. 277, Pl. 8 (fig. 12)
1911 – *Prosopon oxythyreiforme* G. G. Gemmellaro *in* Blaschke; p. 151
1913 – *Prosopon oxythyreiforme* G. G. Gemmellaro *in* Joukowski & Favre; p. 489, Pl. 34 (fig. 8)
1925 – *Prosopon oxythyreiforme* G. G. Gemmellaro *in* Van Straelen; p. 374, Text-fig. 169
1928 – *Oxythyreus oxythyreiforme* (G. G. Gemmellaro) *in* Beurlen; p. 150
1929 – *Cyclothyreus oxythyreiforme* (G. G. Gemmellaro) *in* Glaessner; p. 132
1998 – *Cyclothyreus oxythyreiformis* (G. G. Gemmellaro) *in* Müller; p. 20

Holotype: unknown.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: G. G. Gemmellaro (1869) reported three specimens from Villabate and Misilmeri (Palermo) (MGUP, catalogue number unknown).
Note: this species is also reported from the Upper Jurassic (Tithonian) of Germany and Austria, and the Lower Cretaceous (Neocomian) of France.

Cyclothyreus reussi (G. G. Gemmellaro, 1869)

1869 – *Prosopon reussi* G. G. Gemmellaro; p. 13, Pl. 2 (figs. 52-54)
1925 – *Cyclothyreus reussi* (G. G. Gemmellaro) *in* Van Straelen; p. 376
1929 – *Pithonoton reussi* (G. G. Gemmellaro) *in* Glaessner; p. 326
1998 – *Cyclothyreus reussi* (G. G. Gemmellaro) *in* Wehner; p. 69
2000 – *Cyclothyreus reussi* (G. G. Gemmellaro) *in* Müller, Krobicki & Wehner; Text-fig. 21

Holotype: unknown.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.
Material: G. G. Gemmellaro (1869) reported many specimens from Villabate (Palermo) (MGUP, catalogue number unknown).

Cyclothyreus tithonium (G. G. Gemmellaro, 1869)

1869 – *Prosopon tithonium* G. G. Gemmellaro; p. 14, Pl. 2 (figs. 55-57)
1925 – *Cyclothyreus tithonium* (G. G. Gemmallaro) *in* Van Straelen; p. 377
1929 – *Pithonoton tithonium* (G. G. Gemmellaro) *in* Glaessner; p. 326
1998 – *Cyclothyreus tithonium* (G. G. Gemmellaro) *in* Wehner; p. 69

Holotype: unknown.
Stratigraphic range: Upper Jurassic (Tithonian).
Occurrence: Sicilia.

Material: G. G. Gemmellaro (1869) reported two specimens from Villabate (Palermo) (MGUP, catalogue number unknown).

Dromilites H. Milne Edwards, 1837

Type species: *Dromia bucklandii* H. Milne Edwards, 1837.
Stratigraphic range: Paleocene – Miocene.

Dromilites corvini (Bittner, 1893)

1893 – *Dromia corvinii* Bittner; p. 16, Pl. 2 (fig. 6)
1898 – *Dromia corvini* Bittner *in* Lörenthey; p. 118
1928 – *Dromia corvini* Bittner *in* Beurlen; p. 168
1929 – *Dromia corvini* Bittner *in* Glaessner, p. 138
1929 – *Dromilites corvini* (Bittner) *in* Lörenthey & Beurlen; p. 98, Pl. 4 (figs. 6-7)
2001 – *Dromilites corvini* (Bittner) *in* Beschin, De Angeli & Checchi; p. 17, Text-fig. 3, Pl. 1 (figs. 6-7)
2001 – *Dromilites corvini* (Bittner) *in* De Angeli & Beschin; p. 13

Holotype: unknown.
Stratigraphic range: upper Eocene (Priabonian) – lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported three specimens (MCZ 2123, 2125, 2126) from Castelgomberto (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Dromilites hilarionis (Bittner, 1883)

1883 – *Dromia Hilarionis* Bittner; p. 306, Pl. 1 (fig. 5)
1910a – *Dromia Hilarionis* Bittner *in* Fabiani; p. 25
1915 – *Dromia Hilarionis* Bittner *in* Fabiani; p. 284
1928 – *Pseudodromilites hilarionis* (Bittner) *in* Beurlen; p. 168
1929 – *Dromilites hilarionis* (Bittner) *in* Glaessner; p. 140
1983 – *Dromilites hilarionis* (Bittner) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 57, Pl. 1 (fig. 4)
1989 – *Dromilites hilarionis* (Bittner) *in* Solè & Via Boada; p. 28
1995 – *Dromilites hilarionis* (Bittner) *in* De Angeli; p. 12, Text-fig. 2 (5), Pl. 1 (fig. 6)
2001 – *Dromilites hilarionis* (Bittner) *in* De Angeli & Beschin; p. 13
2004 – *Dromilites hilarionis* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Dromilites hilarionis* (Bittner) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 14, Pl. 2 (fig. 7)

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priaboanian).
Occurrence: Veneto.
Material: Bittner (1883) reported one specimen from Ciupio (Verona) (repository and catalogue number unknown); Busulini *et al.* (1893) reported four specimens (*5, *7, *134; MSNVE 10090) from "Main" quarry of Arzignano (Vicenza); De Angeli (1995) reported one specimen (MCZ 1494) from "Fontanella" di Grancona (Vicenza); Beschin *et al.* (2005) reported two specimens (MCZ 2345; MV 51) from Grola di Cornedo Vicentino (Vicenza).

Note: this species is also reported from the middle/upper Eocene (Lutetian – Priabonian) of Spain.

Dromilites pastoris Via Boada, 1959

1959 – *Dromilites pastoris* Via Boada; p. 364, Text-fig. 6
1969 – *Dromilites pastoris* Via Boada *in* Via Boada; p. 99, Pl. 4 (fig. 5)
1983 – *Dromilites pastoris* Via Boada *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 58, Pl. 1 (fig. 1 a-b)
1989 – *Dromilites pastoris* Via Boada *in* Solè & Via Boada; p. 28
1994 – *Dromilites pastoris* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 165, Pl. 1 (fig. 3)
2001 – *Dromilites pastoris* Via Boada *in* De Angeli & Beschin; p. 14
2004 – *Dromilites pastoris* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Dromilites pastoris* Via Boada *in* Beschin, De Angeli, Checchi & Zarantonello; p. 15, Pl. 2 (fig. 8)

Holotype: MGSB 15.995.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1983) reported two specimens (*136; MSNVE 10091) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported one specimen (MCZ 1456) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported three specimens (MCZ 2285, 2286, 2287) from Grola di Cornedo Vicentino (Vicenza).
Note: this species is also reported from the Eocene of Spain.

Dynomene Desmarest, 1823

Type species: *Dynomene ispida* Guérin-Méneville, 1832.
Stratigraphic range: Oligocene – Recent.

Dynomene lessinea Beschin, De Angeli & Checchi, 2001

2001 – *Dynomene lessinea* Beschin, De Angeli & Checchi; p. 17, Text-fig. 4, Pl. 1 (figs. 5, 8)
2001 – *Dynomene lessinea* Beschin, De Angeli & Checchi *in* De Angeli & Beschin; p. 14

Holotype: MCZ 2065 (I.G. 286420).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported five specimens (MCZ 2065, from 2089 to 2092) from Castelgomberto (Vicenza).

Gemmellarocarcinus Checchia-Rispoli, 1905

Type species: *Gemmellarocarcinus lorentheyi* Checchia-Rispoli, 1905.
Stratigraphic range: middle Eocene (Lutetian).

Gemmellarocarcinus lorentheyi Checchia-Rispoli, 1905

1905 – *Gemmellarocarcinus lörentheyi* Checchia-Rispoli; p. 316, Pl. 1 (figs. 1-2)

1929 – *Gemmellarocarcinus lörentheyi* Checchia-Rispoli *in* Glaessner; p. 182
1933 – *Gemmellarocarcinus lörentheyi* Checchia-Rispoli *in* Di Salvo; p. 33
1969 – *Gemmellarocarcinus lörentheyi* Checchia-Rispoli *in* Via Boada; p. 379
1975 – *Gemmellarocarcinus lorentheyi* Checchia-Rispoli *in* Müller; p. 510, 516
1991 – *Gemmellarocarcinus lorentheyi* Checchia-Rispoli *in* Müller & Collins; p. 64, Pl. 2 (fig. 15)

Holotype: MGUP.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1905) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown); Di Salvo (1933) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Graptocarcinus Roemer, 1887

Type species: *Graptocarcinus texanus* Roemer, 1887.
Stratigraphic range: Lower/Upper Cretaceous.

Graptocarcinus bellonii Collins & Dieni, 1995

1995 – *Graptocarcinus bellonii* Collins & Dieni; p. 70, Text-figs. 2 (1, 2, 4)
2006a – *Graptocarcinus bellonii* Collins & Dieni *in* De Angeli & Garassino; p. 279, Text-fig. 6

Holotype: MGPD B241.
Stratigraphic range: Upper Cretaceous (Maastrichtian).
Occurrence: Friuli-Venezia Giulia.
Material: Collins & Dieni (1995) reported one specimen (MGPD B241) from Col dei Schiosi (Pordenone); De Angeli & Garassino (2006a) reported one specimen (MFSN 16937) from Borgo Vigant (Udine).

Kromtitis Müller, 1984

Type species: *Dromilites koberi* Bachmayer & Tollmann, 1953.
Stratigraphic range: Eocene – Miocene.

Kromtitis tetratuberculatus Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Kromtitis tetratuberculatus* Beschin, Busulini, De Angeli & Tessier; p. 12, Text-fig. 7, Pl. 2 (figs. 2-3 a-b)
2004 – *Kromtitis tetratuberculatus* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113

Holotype: MCZ 2266 (I.G. 296394).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported three specimens (MCZ 2266, 2267, 2268) from "Main" quarry of Arzignano (Vicenza).

Palaeodromites A. Milne Edwards, 1865

Type species: *Cyphonotus incertus* Bell, 1863.
Stratigraphic range: Upper Jurassic – Upper Cretaceous.

Palaeodromites himeraensis (Checchia-Rispoli, 1914)

1914 – *Distefania himeraensis* Checchia-Rispoli; p. 177, Text-figs. 1-2., Pl. 1 (figs. 2-3)
1914 – *Distefania sicula* Chechia-Rispoli; p. 181, Text-figs. 3-4, Pl. 1 (fig. 1), **nov. syn.**
1950 – *Cyphonotus himeraensis* (Checchia-Rispoli) *in* Wright & Wrigth; p. 22, Text-fig. 11
1972 – *Palaeodromites himeraensis* (Checchia-Rispoli) *in* Wright & Collins; p. 51, Text-fig. 9 (f)

Holotype: unknown.
Stratigraphic range: Upper Cretaceous (Cenomanian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1914) reported two specimens from Termini Imerese (Palermo) (repository and catalogue number unknown).
Note: Wright & Collins (1972) considered *P. sicula* as synonym with *P. himeraensis*.

Subsection Archaeobrachyura Guinot, 1977
Superfamily Raninoidea De Haan, 1839
Family Raninidae De Haan, 1839

Cosmonotus Adams & Withe, 1848

Type species: *Cosmonotus grayi* Adams & Withe, 1848.
Stratigraphic range: Eocene – Recent.

Cosmonotus eocaenicus Beschin, Busulini, De Angeli & Tessier, 1988

1988 – *Cosmonotus eocaenicus* Beschin, Busulini, De Angeli & Tessier; p. 160, Text-fig. 2, Pl. 1 (figs. 1-4)
2001 – *Cosmonotus eocaenicus* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 20
2004 – *Cosmonotus eocaenicus* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113

Holotype: MCZ 1105 (I.G. 211644).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988) reported four specimens (MCZ from 1105 to 1108) from "Main" quarry of Arzignano (Vicenza).

Cyrtorhina Monod, 1956

Type species: *Cyrtorhina granulosa* Monod, 1956.
Stratigraphic range: Eocene – Recent.

Cyrtorhina globosa Beschin, Busulini, De Angeli & Tessier, 1988

1988 – *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier; p. 163, Text-fig. 3, Pl. 2 (fig. 1 a-d)

1998 – *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier *in* Rizzotto; p. 21, Pls. 1-2
2001 – *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 14, Text-figs. 10 (4 a-c), 11
2004 – *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2004 – *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier *in* Tessier, Busulini, Beschin & De Angeli; p. 9, Text-figs. 4 a-c, 5
2005 – *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 16

Holotype: MCZ 1135 (I.G. 211671).
Stratigraphic range: lower/middle Eocene (Ypresian–Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988) reported one specimen (MCZ 1135) from "Boschetto" quarry of Chiampo (Vicenza); Rizzotto (1998) reported one specimen (MCZ 1614) from "Main" quarry of Arzignano (Vicenza); Tessier *et al.* (2004) reported one specimen (MGPD 29012) from Zovo of Bolca (Verona).

Cyrtorhina oblonga Beschin, Busulini, De Angeli & Tessier, 1988

1988 – *Cyrtorhina oblonga* Beschin, Busulini, De Angeli & Tessier; p. 166, Text-fig. 4, Pl. 3 (figs. 1-3)
1997 – *Cyrtorhina oblonga* Beschin, Busulini, De Angeli & Tessier *in* Vicariotto; p. 29, Text-fig. 2 a-b
2001 – *Cyrtorhina oblonga* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 16, Text-fig. 10 (1 a-b)
2004 – *Cyrtorhina oblonga* Beschin, Busulini, De Angeli & Tessier *in* Tessier, Busulini, Beschin & De Angeli; Text-fig. 7
2004 – *Cyrtorhina oblonga* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Cyrtorhina oblonga* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 15, Pl. 3 (fig. 1)

Holotype: MCZ 1100 (I.G. 211639).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988) reported six specimens (MCZ 1100, 1101, 1102, 1103, 1104; SV 230) from "Main" quarry of Arzignano (Vicenza); Vicariotto (1997) reported one specimen (MCZ 1577) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2288) from Grola di Cornedo Vicentino (Vicenza).

Lianira Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991

Type species: *Lianira beschini* Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991.
Stratigraphic range: middle Eocene (Lutetian).

Lianira beschini Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991

1991 – *Lianira beschini* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 197, Text-fig. 4, Pl. 1 (fig. 1 a-e), Pl. 2 (figs. 1-2 a-c), Pl. 3 (fig. 1 a-d)
1994 – *Lianira beschini* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, Busulini, De Angeli & Tessier; p. 175, Pl. 4 (figs. 1-2 a-b)
1998 – *Lianira beschini* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 22, Text-figs. 9 (1), 10 (1-3)
2000 – *Lianira beschini* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Lianira beschini* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* De Angeli & Beschin; p. 20, Text-fig. 14 (3 a-c)

Holotype: MCZ 1231 (I.G. 211746).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1991, 1994) reported four specimens (SV 278; MCZ 1231, 1232, 1233) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (1998) reported one specimen (MCZ 1537) from "Rossi" quarry of Monte di Malo (Vicenza).

Lianira convexa Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991

1991 – *Lianira convexa* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 199, Text-fig. 5, Pl. 4 (figs. 1 a-b, 3 a-c)
1994 – *Lianira convexa* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, Busulini, De Angeli & Tessier; p. 176, Pl. 4 (fig. 4)
1998 – *Lianira convexa* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 22, figs. 9 (4), 10 (4-6)
2000 – *Lianira convexa* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Lianira convexa* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* De Angeli & Beschin; p. 20, Text-fig. 14 (4 a-c)
2004 – *Lianira convexa* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* Beschin, Busulini, De Angeli & Tessier; p. 113

Holotype: MCZ 1219 (I.G. 211734).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1991, 1994) reported nine specimens (MCZ from 1217 to 1222, 1303, 1316, 1317) from "Main" quarry of Arzignano (Vicenza) and "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (1998) reported one specimen (MCZ 1538) from "Rossi" quarry of Monte di Malo (Vicenza).

Lophoranina Fabiani, 1910

Type species: *Ranina marestiana* König, 1825.
Stratigraphic range: Upper Cretaceous – Oligocene.

Lophoranina aldrovandii Ronzani, 1818

1594 – *Sepites in* Aldrovandi; carte 224, 225, 251
1648 – Sepites *in* Ambrosino; p. 452
1818 – *Ranina Aldrovandi* Ronzani; p. 76, Pl. 5 (figs. 3, 4)
1822 – *Ranina Aldrovandi* Ronzani *in* Desmarest: p. 121, Pl. 6 (fig. 1), not Pl. 10 (figs. 5-7)
1837 – *Ranina Aldrovandi* Ronzani *in* A. Milne Edwards; p. 195
1838 – *Ranina Aldrovandi* Ronzani *in* A. Milne Edwards *in* Lamarck; p. 195
1846 – *Ranina Aldrovandi* Ronzani *in* E. Sismonda; p. 64

1859 – *Ranina Aldrovandi* Ronzani *in* Reuss; p. 19, 20
1861 – *Ranina Aldrovandi* Ronzani *in* E. Sismonda; p. 17, non Text-figs. 16-17
1861 – *Hippa Aldrovandi* (Ronzani) *in* A. Milne Edwards *in* Cuvier; p. 106
1861 – *Ranina aldrovandi* Ronzani *in* Michelotti; p. 141
1866 – *Ranina Aldrovandi* Ronzani *in* Woodward; p. 591
1872 – *Ranina Aldrovandi* Ronzani *in* A. Milne Edwards; p. 7
1875 – *Ranina Aldrovandi* Ronzani *in* Bittner; p. 4
1889 – *Ranina Aldrovandi* Ronzani *in* Ristori; p. 408
1907 – *Ranina Aldrovandi* Ronzani *in* Gortani; p. 10
1910b – *Ranina* (*Lophoranina*) *Aldrovandii* Ronzani *in* Fabiani; p. 95, Text-figs. 1-4
1929 – *Ranina* (*Lophoranina*) *Aldrovandii* Ronzani *in* Glaessner, p. 364
1966 – *Lophoranina aldrovandi* (Ronzani) *in* Via Boada; p. 254
1969 – *Lophoranina aldrovandi* (Ronzani) *in* Via Boada; p. 119, 391
1974 – *Ranina aldrovandii*? (Ronzani) *in* Mastrorilli; p. 4
1988 – *Lophoranina aldrovandii* (Ronzani) *in* Beschin, Busulini, De Angeli & Tessier; p. 188

Holotype: MPP Geo 00000046 (ex number G10415Rocc/49336)
Stratigraphic range: ?Eocene.
Occurrence: ?NE Italy.
Material: Ronzani (1818), Reuss (1859) and Fabiani (1910b) reported the species probably from the Eocene of N Italy.

Lophoranina bittneri (Lörenthey, 1902)

1875 – *Ranina* nov. spec.? *in* Bittner; p. 66, Pl. 1 (fig. 3)
1898 – *Ranina* cfr. *Marestiana in* Lörenthey; p. 22
1902 – *Ranina Bittneri* Lörenthey; p. 809, Pl. 1 (figs. 1-2)
1905 – *Ranina Bittneri* Lörenthey *in* Airaghi; p. 203, Pl. 4 (fig. 1)
1910a – *Ranina Bittneri* Lörenthey *in* Fabiani, p. 20
1910b – *Ranina* (*Lophoranina*) *Bittneri* Lörenthey *in* Fabiani; p. 90
1915 – *Ranina Bittneri* Lörenthey *in* Fabiani; p. 284, 285
1929 – *Ranina* (*Lophoranina*) *Bittneri* Lörenthey *in* Lörenthey & Beurlen; p. 114, Pl. 5 (figs. 2-3)
1929 – *Ranina* (*Lophoranina*) *Bittneri* Lörenthey *in* Glaessner, p. 365
1933 – *Ranina Bittneri* Lörenthey *in* Di Salvo; p. 13, Pl. 1 (fig. 4 a-b)
1966 – *Ranina bittneri* Lörenthey *in* Ancona; p. 406
1983 – *Lophoranina bittneri* (Lörenthey) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 60, Pl. 1 (fig. 5)
1988 – *Lophoranina bittneri* (Lörenthey) *in* Beschin, Busulini, De Angeli & Tessier; p. 179, Text-fig. 7 (3), Pl. 6 (figs. 2-4)
1998 – *Lophoranina bittneri* (Lörenthey) *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 20, Text-fig. 8 (3)
2000 – *Lophoranina bittneri* (Lörenthey) *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Lophoranina bittneri* (Lörenthey) *in* De Angeli & Beschin, p. 17, Text-fig. 13 (5)

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto, Sicilia.
Material: Bittner (1875) reported this species from Monte Zuello, Ciupio (Verona) (repository and catalogue number unknown); Airaghi (1905) reported one specimen from Lonigo (Vicenza) (MNAV, catalogue number unknown); Di Salvo (1933) reported one specimen Ponte di Castronuovo (Palermo) (MGUP, catalogue number unknown); Busulini *et al.* (1983) reported one specimen (*141) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1988, 1998) reported four specimens (MSNVE 11877, 11878, MCZ 1117, 1118) from Castello di Soave (Verona) and "Rossi" quarry of Monte di Malo (Vicenza).

Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Lophoranina laevifrons (Bittner, 1875)

1875 – *Ranina laevifrons* Bittner; p. 68, Pl. 1 (fig. 4)
1895 – *Ranina laevifrons* Bittner *in* Bittner; p. 247, Pl. 1 (figs. 3-4)
1910a – *Ranina laevifrons* Bittner *in* Fabiani; p. 20
1910b – *Ranina* (*Lophoranina*) *laevifrons* Bittner *in* Fabiani; p. 90
1915 – *Ranina laevifrons* Bittner *in* Fabiani; p. 284
1966 – *Ranina laevifrons* Bittner *in* Ancona; p. 406
1983 – *Lophoranina laevifrons* (Bittner) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 61, Pl. 2 (fig. 4)
1988 – *Lophoranina laevifrons* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 181, Text-fig. 7 (4-6), Pl. 7 (figs. 3-5)
1994 – *Lophoranina laevifrons* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 174, Pl. 3 (fig. 3)
2001 – *Lophoranina laevifrons* (Bittner) *in* De Angeli & Beschin; p. 18, Text-fig. 13 (4 a-b)
2004 – *Lophoranina laevifrons* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 113
2005 – *Lophoranina laevifrons* (Bittner) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 16, Pl. 3 (fig. 3)

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875, 1895) reported two specimens from S. Giovanni Ilarione (Verona) (repository and catalogue number unknown); Busulini *et al.* (1983) reported one specimen (*36) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1988) reported six specimens (SV 36, 279, 280, 281; MCZ 1115, 1116) from "Albanello" and "Boschetto" quarries of Nogarole Vicentino, "Main" quarry of Arzignano (Vicenza), and Crocegrande (Verona); Beschin *et al.* (1994) reported five specimens (MCZ 1261, 1262, 1263, 1275, 1435) from "Albanello" and "Boschetto" quarries of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2344) from Grola di Cornedo Vicentino (Vicenza).

Lophoranina marestiana (König, 1825)

1817 – *Remipes sulcatus in* Desmarest; p. 512
1822 – *Ranina Aldrovandi in* Desmarest; p. 512
1825 – *Ranina Maresiana* König; p. 2, Pl. 1 (fig. 15, *R. Maretiana*)
1854 – *Ranina Aldrovandii* Ronzani *in* Catullo; p. 886
1859 – *Ranina Marestiana* König *in* Reuss; p. 20, Pl. 5 (figs. 1-2)
1872 – *Ranina Maresiana* (*sic!*) König *in* A. Milne Edwards; p. 8
1875 – *Ranina Marestiana* König *in* Bittner; p. 64, Pl. 1 (figs. 1-2)
1883 – *Ranina Marestiana* König *in* Bittner; p. 300, Pl. 1 (figs. 1-2)
1908 – *Ranina Marestiana* König *in* Fabiani; p. 209, 236
1910a – *Ranina marestiana* König *in* Fabiani; p. 19
1910b – *Ranina* (*Lophoranina*) *marestiana* König *in* Fabiani; p. 89
1915 – *Ranina marestiana* König *in* Fabiani; p. 284, 285
1915 – *Ranina marestiana* König *in* Dainelli; p. 699

1933 – *Ranina* cfr. *Marestiana* König *in* Di Salvo; p. 12
1959 – *Lophoranina marestiana* (König) *in* Via Boada; p. 365
1966 – *Ranina marestiana* König *in* Ancona; p. 402, Text-figs. 1-2, Pls. 1-3
1966 – *Lophoranina marestiana* (König) *in* Via Boada; p. 240, Text-figs. 1-3, Pl. 1
1968 – *Ranina* (*Lophoranina*) *marestiana* (König) *in* Vogeltanz; p. 33
1969 – *Lophoranina marestiana* (König) *in* Via Boada; p. 104, Text-fig. 11, Pl. 5 (fig. 1), Pl. 6 (fig. 1)
1988 – *Lophoranina marestiana* (König) *in* Beschin, Busulini, De Angeli & Tessier; p. 175, Text-fig. 6, Pl. 5 (figs. 2-4), Pl. 6 (fig. 1 a-c)
1994 – *Lophoranina marestiana* (König) *in* Beschin, Busulini, De Angeli & Tessier; p. 173, Pl. 3 (fig. 4)
1998 – *Lophoranina marestiana* (König) *in* Beschin Busulini, De Angeli, Tessier & Ungaro; p. 20, Text-figs. 6 (2-3), 8 (1)
1998 – *Lophoranina marestiana* (König) *in* Müller; p. 25
2000 – *Lophoranina marestiana* (König) *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Lophoranina marestiana* (König) *in* De Angeli & Beschin; p. 17, Text-figs. 12-13 (1 a-c)
2006a – *Lophoranina marestiana* (König) *in* De Angeli & Garassino; p. 280, Text-fig. 7 (a-b)

Holotype: unknown.
Stratigraphic range: lower/upper Eocene (Ypresian – Priabonian).
Occurrence: Veneto, Friuli-Venezia Giulia, Sicilia.
Material: Reuss (1859), A. Milne Edwards (1872), Bittner (1875, 1883) reported this species from Vicenza and Verona (repository and catalogue number unknown); Dainelli (1915) reported four specimens from Buttrio and Valle del Natisone (Pordenone) (repository and catalogue number unknown); Di Salvo (1933) reported two specimens from Ponte di Castronuovo and Torre Malfitano (Palermo) (MGUP, catalogue number unknown); Ancona (1966) reported this species from "Zanconato" quarry of Chiampo (Vicenza) (MCSM, catalogue number unknown); Beschin *et al.* (1988, 1994, 1998) reported 18 specimens (SV 293, 294, 297, 298, 299, 300, 302, 315, 316; MSNVE from 11873 to 11876; MCZ from 1121 to 1125, 1331, 1536) from Chiampo and "Rossi" quarry of Monte di Malo (Vicenza); De Angeli & Garassino (2006a) reported four specimens (MFSN from 29047 to 29050) from Almadis (Pordenone).
Note: this species is also reported from Eocene of Spain, Austria, and N Africa.

Lophoranina marestiana var. *avesana* (Bittner, 1883)

1883 – *Ranina Marestiana* var. *avesana* Bittner; p. 301, Pl. 1 (fig. 2)
1884 – *Ranina Marestiana* var. *avesana* Bittner *in* Bittner; p. 16, Pl. 1 (figs. 1-3)
1929 – *Ranina* (*Lophoranina*) *Marestiana* var. *avesana* Bittner *in* Glaessner, p. 367

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1883, 1884) reported seven specimens from Avesa Valley (Verona), belonging to Nicolisi's collection (repository and catalogue number unknown).

Lophoranina maxima Beschin, Busulini, De Angeli & Tessier, 2004

1988 – *Lophoranina* cf. *reussi* Woodward *in* Beschin, Busulini, De Angeli & Tessier; p. 185, Text-fig. 8, Pl. 5 (fig. 1), Pl. 8 (figs. 1-4), Pl. 9 (fig. 1)
2001 – *Lophoranina* cf. *reussi* Woodward *in* De Angeli & Beschin; p. 18
2004 – *Lophoranina maxima* Beschin, Busulini, De Angeli & Tessier; p. 110, Text-figs. 1-2, Pl. 1 (figs.1-3), Pl. 2 (figs. 1-2)

Holotype: MCZ 1127 (I.G. 211663).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988, 2004) reported eight specimens (SV 37, from 318 to 322; MCZ 1127; MCSM, catalogue number unknown) from "Main" quarry of Arzignano (Vicenza).

Lophoranina reussi (Woodward, 1866)

1859 – *Ranina* sp. *in* Reuss; p. 21, Pl. 5 (figs. 3-4)
1866 – *Ranina Reussii* Woodward; p. 591
1883 – *Ranina Reussii* Woodward *in* Bittner; p. 302
1898 – *Ranina Reussi* Woodward *in* Lörenthey; p. 18, Pl. 2 (fig. 1)
1899 – *Ranina Reussi* Woodward *in* Oppenheim; p. 58
1905 – *Ranina Reussi* Woodward *in* Airaghi; p. 203, Pl. 4 (fig. 2)
1908 – *Ranina Reussi* Woodward *in* Fabiani; p. 210, 236
1910a – *Ranina Reussi* Woodward *in* Fabiani; p. 19
1910b – *Ranina* (*Lophoranina*) *Reussi* Woodward *in* Fabiani; p. 89
1915 – *Ranina Reussi* Woodward *in* Fabiani; p. 284, 285
1929 – *Ranina* (*Lophoranina*) *Reussi* Woodward *in* Lörenthey & Beurlen; p. 111, Pl. 5 (fig. 1)
1959 – *Lophoranina reussi* (Woodward) *in* Via Boada; p. 365
1966 – *Lophoranina reussi* (Woodward) *in* Via Boada; p. 246, Text-fig. 4, Pl. 2 (figs. 1-3)
1966 – *Ranina reussi* Woodward *in* Ancona; p. 406
1969 – *Lophoranina reussi* (Woodward) *in* Via Boada; p. 110, Text-fig. 12, Pl. 5 (fig. 2), Pl. 6 (figs. 2-4)
1988 – *Lophoranina reussi* (Woodward) *in* Beschin, Busulini, De Angeli & Tessier; p. 183, Text-figs. 7 (1-2), Pl. 7 (figs. 1-2)
1995 – *Lophoranina reussi* (Woodward) *in* De Angeli; p. 11
2001 – *Lophoranina reussi* (Woodward) *in* De Angeli & Beschin; p. 18, Text-fig. 13 (2 a-b)
2005 – *Lophoranina reussi* (Woodward) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 16, Pl. 3 (fig. 2)

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Reuss (1859), Bittner (1883), Airaghi (1905) reported this species from Lessini orientali and Monti Berici (repository and catalogue number unknown); Fabiani (1910a) reported this species from Nanto, Montruglio, Castello di Barbarano, Villaga, Sarego, Lonigo and Grancona (Vicenza), and S. Giovanni Ilarione (Verona) (repository and catalogue number unknown); Beschin *et al.* (1988) reported two specimens (SV 309; MCZ 1119) from Villaga and Barbarano (Vicenza); De Angeli (1995) reported one specimen (MCZ 1493) from "Fontanella" di Grancona (Vicenza); Beschin *et al.* (2005) reported three specimens (MCZ 2325, 2326, 2327) from Grola di Cornedo Vicentino (Vicenza).

Note: this species is also reported from the middle Eocene (Lutetian) of Spain and upper Eocene (Priabonian) of Hungary.

Lophoranina straeleni Via Boada, 1959

1959 – *Lophoranina straeleni* Via Boada; p. 366, Text-fig. 7
1969 – *Lophoranina straeleni* Via Boada *in* Via Boada; p. 115, Text-fig. 13, Pl. 7 (fig. 1), Pl. 8 (fig. 1)
1989 – *Lophoranina straeleni* Via Boada *in* Solè & Via Boada; p. 29
1998 – *Lophoranina straeleni* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 22, Text-figs. 6 (5), 8 (2)
2000 – *Lophoranina straeleni* Via Boada *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Lophoranina straeleni* Via Boada *in* De Angeli & Beschin; p. 18

Holotype: MNCNM 1.001.
Stratigraphic range: lower/middle Eocene (Ypresian–Lutetian).
Occurrence: Veneto.
Material: Via Boada (1959, 1969) reported three specimens from Bolca area (Verona) (MS, catalogue number unknown); Beschin *et al.* (1998) reported one specimen (MCZ 1539) from "Rossi" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the middle Eocene (Lutetian) of Spain.

Lophoranina sp.

1982 – *Lophoranina* sp. *in* Busulini, Tessier & Visentin; p. 78

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1982) reported one specimen from "Main" quarry of Arzignano (Vicenza) (SV, catalogue number unknown).

Lovarina Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991

Type species: *Lovarina cristata* Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991.
Stratigraphic range: middle Eocene (Lutetian).

Lovarina cristata Beschin, Busulini, De Angeli, Tessier & Ungaro, 1991

1991 – *Lovarina cristata* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 202, Text-fig. 6, Pl. 5 (figs. 1 a-b, 3)
2001 – *Lovarina cristata* Beschin, Busulini, De Angeli, Tessier & Ungaro *in* De Angeli & Beschin; p. 20, Text-fig. 14 (5 a-c)

Holotype: MCZ 1224 (I.G. 211739).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1991) reported nine specimens (MCZ from 1224 to 1230, 1299, 1318) from "Lovara" quarry of Chiampo (Vicenza).

Lysirude Goeke, 1985

Type species: *Lyreidus tridentatus* De Haan, 1841.
Stratigraphic range: Eocene – Recent.

Lysirude paronae (Crema, 1895)

1895 – *Lyreidus paronae* Crema; p. 671, Text-fig. 11
1907 – *Lyreidus paronae* Crema *in* Sacco; p. 116
1929 – *Lyreidus paronae* Crema *in* Glaessner; p. 241
1998 – *Lysirude paronae* (Crema) *in* Tucker; p. 324
2004 – *Lysirude paronae* (Crema) *in* Garassino, De Angeli, Gallo & Pasini; p. 258, Text-figs. 3-4

Holotype: PU 80111.
Stratigraphic range: middle Miocene (Helvetian) – Pliocene.
Occurrence: Piemonte.
Material: Crema (1895) reported one specimen (PU 80111), from Sciolze (Torino); Garassino *et al.* (2004) reported one specimen (PU 41148) from Orta S. Giulio (Novara).

Notopoides Henderson, 1888

Type species: *Notopoides latus* Henderson, 1888.
Stratigraphic range: Eocene – Recent.

Notopoides exiguus Beschin, Busulini, De Angeli & Tessier, 1988

1988 – *Notopoides exiguus* Beschin, Busulini, De Angeli & Tessier; p. 188, Text-fig. 9, Pl. 9 (figs. 2-3)
2001 – *Notopoides exiguus* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 17, Text-fig. 10 (2)

Holotype: MSNVE 11879.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988) reported three specimens (SV 325 ; MSNVE 11879; MCZ 1128) from "Boschetto" quarry of Chiampo (Vicenza).

Notopus De Haan, 1841

Type species: *Cancer dorsipes* Linnaeus, 1758.
Stratigraphic range: Eocene – Recent.

Notopus beyrichi Bittner, 1875

1875 – *Notopus Beyrichii* Bittner; p. 72, Pl. 1 (fig. 6)
1884 – *Notopus Beyrichii* Bittner *in* Bittner; p. 17, Pl. 1 (fig. 4)
1898 – *Notopus Beyrichii* Bittner *in* Lörenthey; p. 26
1899 – *Notopus Beyrichi* Bittner *in* Oppenheim; p. 58
1910a – *Notopus Beyrichi* Bittner *in* Fabiani; p. 20, 29, 31
1915 – *Notopus Beyrichi* Bittner *in* Fabiani; p. 284
1929 – *Notoporanina Beyrichi* (Bittner) *in* Lörenthey & Beurlen; p. 117, Pl. 5 (fig. 4-6)
1929 – *Notoporanina Beyrichi* (Bittner) *in* Glaessner; p. 278
1950 – *Notopus beyrichi* Bittner *in* Malaroda; p. 191
1982 – *Notopus beyrichi* Bittner *in* Busulini, Tessier & Visentin; p. 78
1988 – *Notopus beyrichi* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 191, Text-fig. 10, Pl. 10 (fig. 1 a-b)
2001 – *Notopus beyrichi* Bittner *in* De Angeli & Beschin; p. 20, Text-fig. 14 (2 a-b)
2004 – *Notopus beyrichi* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 113

2005 – *Notopus beyrichi* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 16, Pl. 3 (fig. 5)
2006 – *Notopus beyrichi* Bittner *in* Beschin, De Angeli, Checchi & Mietto; p. 103, Pl. 2 (fig. 1)

Holotype: MNHB K.107, MB.A. 657.
Stratigraphic range: middle/upper Eocene (Lutetian–Priabonian) and lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Bittner (1875, 1884) reported this species (MNHB K.107, MB.A. 657) from S. Giovanni Ilarione and Castelrotto (Verona); Malaroda (1950) reported one specimen from Montecchio of Costozza (Vicenza) (repository and catalogue number unknown); Busulini *et al.* (1982) reported two specimens from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1988) reported five specimens (SV 274, 304, 306; MCZ1112, 1113) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported two specimens (MCZ 2359; MCV 50) from Grola di Cornedo Vicentino (Vicenza); Beschin *et al.* (2006) reported one specimen (MCZ 2439) from Buso della Rana (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Quasilaeviranina Tucker, 1998

Type species: *Ranina simplicissima* Bittner, 1883.
Stratigraphic range: Eocene.

Quasilaeviranina arzignanensis (Beschin, Busulini, De Angeli & Tessier, 1988)

1988 – *Notosceles arzignanensis* Beschin, Busulini, De Angeli & Tessier; p. 194, Text-fig. 11, Pl. 10 (figs. 2-3)
1998 – *Quasilaeviranina arzignanensis* (Beschin, Busulini, De Angeli & Tessier) *in* Tucker; p. 356
2001 – *Quasilaeviranina arzignanensis* (Beschin, Busulini, De Angeli & Tessier) *in* De Angeli & Beschin; p. 16, Text-fig. 10 (3 a-c)
2004 – *Quasilaeviranina arzignanensis* (Beschin, Busulini, De Angeli & Tessier) *in* Beschin, Busulini, De Angeli & Tessier; p. 113

Holotype: MCZ 1114.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988) reported two specimens (SV 276; MCZ 1114) from "Main" quarry of Arzignano (Vicenza).

Quasilaeviranina ombonii (Fabiani, 1910)

1910a – *Ranina Ombonii* Fabiani; p. 2, Pl. 2 (fig. 1)
1910b – *Ranina Ombonii* Fabiani *in* Fabiani; p. 91
1915 – *Ranina Ombonii* Fabiani *in* Fabiani; p. 284
1929 – *Ranina* (*Laeviranina*) *Ombonii* Fabiani *in* Glaessner; p. 364
1988 – *Laeviranina ombonii* (Fabiani) *in* Beschin, Busulini, De Angeli & Tessier; p. 169, Text-fig. 5 (3), Pl. 3 (figs. 4-6)
1998 – *Quasilaeviranina ombonii* (Fabiani) *in* Tucker; p. 357
2001 – *Quasilaeviranina ombonii* (Fabiani) *in* De Angeli & Beschin; p. 17, Text-fig. 10 (7)

Holotype: MGPD 7820.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Fabiani (1910b) reported one specimen (MGPD 7820) from Villaga (Vicenza); Beschin *et al.* (1988) reported two specimens (MCZ 1131; MSNVE 11872) from Nanto (Vicenza) and Breonio (Verona).

Quasilaeviranina simplicissima (Bittner, 1883)

1883 – *Ranina simplicissima* Bittner; p. 305, Pl. 1 (fig. 4 a-b)
1910a – *Ranina simplicissima* Bittner *in* Fabiani; p. 3
1910b – *Ranina simplicissima* Bittner *in* Fabiani; p. 91
1915 – *Ranina simplicissima* Bittner *in* Fabiani; p. 284
1929 – *Ranina* (*Laeviranina*) *simplicissima* Bittner *in* Glaessner; p. 364
1929 – *Laeviranina simplicissima* (Bittner) *in* Lörenthey & Beurlen; p. 106, Pl. 4 (fig. 11)
1983 – *Laeviranina* cfr. *simplicissima* (Bittner) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 59, Pl. 1 (fig. 3).
1988 – *Laeviranina* cf. *simplicissima* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 173, Text-fig. 5 (1), Pl. 4 (figs. 4-5)
1994 – *Laeviranina* cf. *simplicissima* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 173, Pl. 3 (fig. 2)
1998 – *Quasilaeviranina simplicissima* (Bittner) *in* Tucker; p. 355
2001 – *Quasilaeviranina simplicissima* (Bittner) *in* De Angeli & Beschin; p. 16, Text-fig. 10 (5)
2004 – *Quasilaeviranina simplicissima* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p.113

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1883) reported one specimen from Monte Vegroni of Bolca (Verona) (repository and catalogue number unknown); Busulini *et al.* (1983) reported two specimens (*136; MSNVE 10092) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1988) reported six specimens (SV 136, 326; MSNVE 10092; MCZ from 1132 to 1134,) from "Main" quarry of Arzignano, "Boschetto" and "Albanello" quarries of Nogarole Vicentino (Vicenza); Beschin *et al.* (1994) reported four specimens (MCZ 1133, 1209, 1210, 1272) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).
Note: this species is also reported from the middle Eocene (Lutetian) of Hungary.

Ranilia H. Milne Edwards, 1837

Type species: *Ranilia muricata* H. Milne Edwards, 1837.
Stratigraphic range: Eocene – Recent.

Ranilia punctulata Beschin, Busulini, De Angeli & Tessier, 1988

1988 – *Ranilia punctulata* Beschin, Busulini, De Angeli & Tessier; p. 196, Text-fig. 12, Pl. 11 (figs. 1-2)
1994 – *Ranilia punctulata* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 176, Pl. 4 (fig. 3)
2001 – *Ranilia punctulata* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 22, Text-figs. 14 (1 a-b), 15

Holotype: MCZ 1120 (I.G. 211656).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988) reported four specimens (SV from 311 to 313; MCZ 1120) from "Lovara" and "Boschetto" quarries of Chiampo (Vicenza); Beschin *et al.* (1994) reported three specimens (MCZ 1256, 1415, 1442) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Ranina Lamarck, 1801

Type species: *Ranina ranina* (Linnaeus, 1758) (= *R. serrata* Lamarck, 1801; *R. dentata* Latreille, 1802).
Stratigraphic range: Eocene – Recent.

Ranina bouilleana A. Milne Edwards, 1872

1872 – *Ranina bouilleana* A. Milne Edwards; p. 6, Pl. 8 (figs. 2-2 a-c)
1873 – *Ranina bouilleana* A. Milne Edwards *in* A. Milne Edwards; p. 8, Pl. 4 (fig. 55)
1883 – *Ranina bouilleana* A. Milne Edwards *in* Bittner; p. 303
1910a – *Ranina bouilleana* A. Milne Edwards *in* Fabiani; p. 20
1910b – *Ranina* (*Eteroranina*) *bouilleana* A. Milne Edwards *in* Fabiani; p. 91
1915 – *Ranina bouilleana* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Ranina* (*R.*) *bouilleana* A. Milne Edwards *in* Glaessner; p. 361
2001 – *Ranina bouilleana* A. Milne Edwards *in* De Angeli & Beschin; p. 20

Holotype: unknown.
Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: Bittner (1883) reported one speciemen from Castelli di Montecchio Maggiore (Vicenza) (catalogue number unknown).
Note: this species is also reported from the Oligocene of France.

Ranina palmea E. Sismonda, 1846

1846 – *Ranina palmea* E. Sismonda; p. 64, Pl. 3 (figs. 3-4)
not 1847 – *Ranina palmea* E. Sismonda *in* Michelotti; p. 70 = *Ranina serrata*
1859 – *Ranina palmea* E. Sismonda *in* Reuss; p. 21
1872 – *Ranina palmea* E. Sismonda *in* A. Milne Edwards; p. 4
1895 – *Ranina palmea* E. Sismonda *in* Crema; p. 672, Text-fig. 12 a-e
1910b – *Ranina palmea* E. Sismonda *in* Fabiani; p. 9
1929 – *Ranina palmea* E. Sismonda *in* Glaessner; p. 362

Holotype: lost.
Stratigraphic range: Miocene.
Occurrence: Piemonte.
Material: E. Sismonda (1846) reported one specimen from Torino, today lost; Crema (1895) reported some specimens from Torino, Sciolze and Bardassano (Torino) (repository and catalogue number unknown).

Ranina propinqua Ristori, 1891

1891a – *Ranina propinqua* Ristori; p. 11, Pl. 1 (figs. 4-7)
1910b – *Ranina propinqua* Ristori *in* Fabiani; p. 9
1929 – *Ranina propinqua* Ristori *in* Glaessner; p. 363

Holotype: unknown.
Stratigraphic range: Pliocene.
Occurrence: Umbria.
Material: Ristori (1891a) reported one specimen from Città della Pieve (Umbria) (MGPUR, catalogue number unknown).

Ranina speciosa (Münster, 1840)

1840 – *Hela speciosa* Münster; p. 24, Pl. 2 (figs. 1-3)
1859 – *Ranina speciosa* (Münster) *in* Reuss; p. 22
1875 – *Ranina speciosa* (Münster) *in* Bittner; p. 70, Pl. 1 (fig. 5 a-d)
1886 – *Ranina speciosa* (Münster) *in* Noetling; p. 33
1887 – *Ranina speciosa* (Münster) *in* Ebert; p. 266, Pl. 9 (fig. 1)
1889 – *Ranina speciosa* (Münster) *in* Ristori; p. 406, Pl. 15 (figs. 9-13)
1903 – *Ranina speciosa* (Münster) *in* Oppenheim; p. 196
1910a – *Ranina speciosa* (Münster) *in* Fabiani; p. 20
1910b – *Ranina speciosa* (Münster) *in* Fabiani; p. 8
1929 – *Ranina speciosa* (Münster) *in* Glaessner; p. 363
1974 – *Ranina speciosa* (Münster) *in* Mastrorilli; p. 4
1987 – *Ranina speciosa* (Münster) *in* Allasinaz; p. 529, Text-fig. 9, Pl. 1 (figs. 11-16), Pl. 2 (figs. 1-6), Pl. 3 (figs. 1-8)

Holotype: unknown.
Stratigraphic range: Oligocene – Miocene.
Occurrence: Piemonte, Veneto, Liguria.
Material: Oppenheim (1903) and Bittner (1875) reported this species from "Brocchi" quarry (Bassano – Vicenza) and Monfumo (Treviso) respectively (repository and catalogue number unknown); Ristori (1889) described 13 specimens from Sassello (Savona), housed in don Perrando's collection today in the "DIP.TE.RIS" (we identified two original specimens: 2391/Sa-II-S188 (ex Sa-II-S183) and 2392/Sa-II-S189 (ex Sa-II-S183), figured in Pl. 15, figs. 9, 11) and in Michelotti's collection (SGR, catalogue number unknown); Allasinaz (1987) reported 30 specimens from Ciglione, Torrente Aimone and Rio Volpina, and Ponzone (Acqui) (PU; MCSN, catalogue number unknown).
Note: this species is also reported from Osnabrück and Cassel (Germany).

Raninoides H. Milne Edwards, 1837

Type species: *Ranina laevis* Latreille, 1825.
Stratigraphic range: Eocene – Recent.
Note: Schweitzer *et al.* (in press) considered *Laeviranina* Lörenthey (*in* Lörenthey & Beurlen, 1929) as synonym with *Raninoides* H. Milne Edwards, 1837.

Raninoides budapestiniensis (Lörenthey, 1897)

1897 – *Ranina budapestiniensis* Lörenthey; p. 153, 166
1898 – *Ranina budapestinensis* Lörenthey *in* Lörenthey; p. 23, Pl. 1 (fig. 2)
1929 – *Laeviranina budapestinensis* (Lörenthey) *in* Lörenthey & Beurlen; p. 107, Pl. 4 (fig. 12)
1929 – *Ranina* (*Laeviranina*) *budapestinensis* Lörenthey *in* Glaessner; p. 364

1994 – *Laeviranina budapestiniensis* (Lörenthey) *in* Beschin, Busulini, De Angeli & Tessier; p. 172, Pl. 3 (fig. 1 a-c)
2001 – *Laeviranina budapestiniensis* (Lörenthey) *in* De Angeli & Beschin; p. 16

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported one specimen (MCZ 1295) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Raninoides fabianii (Lörenthey & Beurlen, 1929)

1929 – *Laeviranina Fabianii* Lörenthey & Beurlen; p. 105, Pl. 4 (fig. 10)
1929 – *Ranina* (*Laeviranina*) *fabianii* Lörenthey *in* Glaessner; p. 364
1931 – *Laeviranina fabianii* Lörenthey & Beurlen *in* Glaessner & Withers; p. 491
1935 – *Ranina* (*Laeviranina*) *fabianii* Lörenthey & Beurlen *in* Roger; p. 352, Pl. 9 (fig. 5)
1969 – *Laeviranina fabianii* Lörenthey & Beurlen *in* Glaessner; p. 364
1969 – *Laeviranina fabianii* Lörenthey & Beurlen *in* Via Boada; p. 391
1982 – *Laeviranina fabianii* Lörenthey & Beurlen *in* Förster & Mundlos; p. 156, Pl. 1 (figs. 4-6)
1998 – *Laeviranina fabianii* Lörenthey & Beurlen *in* Tucker; p. 351
2006 – *Laeviranina fabianii* Lörenthey & Beurlen *in* Beschin, De Angeli, Checchi & Mietto; p. 103, Pl. 2 (figs. 2-3)

Holotype: unknown.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (2006) reported six specimens (MCZ from 2433 to 2438) from Val Segato, Grotta della Poscola, and Buso della Rana (Vicenza).
Note: this species is also reported from tha middle/upper Eocene (Lutetian – Priabonian) of Hungary and Germany.

Raninoides cfr. *R. fabianii* (Lörenthey & Beurlen, 1929)

1998 – *Laeviranina* cfr. *fabianii* Lörenthey & Beurlen *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 18, Text-figs. 7, 9 (2)
2000 – *Laeviranina* cfr. *fabianii* Lörenthey *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Laeviranina* cfr. *fabianii* Lörenthey & Beurlen *in* De Angeli & Beschin; p. 16

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1998) reported one specimen (MCZ 1541) from "Rossi" quarry of Monte di Malo (Vicenza).

Raninoides notopoides (Bittner, 1883)

1883 – *Ranina notopoides* Bittner; p. 304, Pl. 1 (fig. 3)
1910b – *Ranina* (*Eteroranina*) *notopoides* Bittner *in* Fabiani; p. 91
1915 – *Ranina notopoides* Bittner *in* Fabiani; p. 284
1929 – *Ranina* (*R.*) *notopoides* Bittner *in* Glaessner; p. 362
1969 – *Laeviranina notopoides* (Bittner) *in* Via Boada; p. 124, 388

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1883) reported one specimen from Monte Masua of Negrar (Verona) (repository and catalogue number unknown).

Raninoides pulchra (Beschin, Busulini, De Angeli & Tessier, 1988)

1988 – *Laeviranina pulchra* Beschin, Busulini, De Angeli & Tessier; p. 171, Text-fig. 5 (2), Pl. 4 (figs. 1-3)
1997 – *Laeviranina pulchra* Beschin, Busulini, De Angeli & Tessier *in* Vicariotto; p. 29, Text-fig. 1 a-b
2001 – *Laeviranina pulchra* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 16, Text-fig. 10 (6)
2004 – *Laeviranina pulchra* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 113

Holotype: MCZ 1126 (I.G. 211662).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1988)) reported three specimens (SV 250; MCZ 1126, 1129) from "Main" quarry of Arzignano (Vicenza); Vicariotto (1997) reported one specimen (MCZ 1576) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Tribolocephalus Ristori, 1886

Type species: *Tribolocephalus laevis* Ristori, 1886.
Stratigraphic range: Pliocene.

Tribolocephalus laevis Ristori, 1886

1886 – *Tribolocephalus laevis* Ristori; p. 128, Pl. 2 (fig. 19)
1927 – *Tribolocephalus laevis* Ristori *in* Van Straelen; p. 85
1929 – *Tribolocephalus laevis* Ristori *in* Glaessner; p. 388
1969 – *Tribolocephalus laevis* Ristori *in* Glaessner; p. 502
1981 – *Tribolocephalus laevis* Ristori *in* Delle Cave; p. 45

Holotype: IGF 616E.
Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1886) reported one specimen (IGF 616E) from Orciano (Pisa).

Section Eubrachyura de Saint Laurent, 1980
Subsection Heterotremata Guinot, 1977
Superfamily Dorippoidea MacLeay, 1838
Family Dorippidae MacLeay, 1838

Medorippe Manning & Holthuis, 1981

Type species: *Dorippe lanata* Linnaeus, 1767.
Stratigraphic range: Miocene – Recent.

Medorippe ampla Garassino, De Angeli, Gallo & Pasini, 2004

2004 – *Medorippe ampla* Garassino, De Angeli, Gallo & Pasini; p. 260, Text-figs. 5-6 a-b

Holotype: PU 41149.
Stratigraphic range: upper Miocene (Messinian).
Occurrence: Piemonte.
Material: Garassino *et al.* (2004) reported two specimens (PU 41149, 41197) from Cocconato (Asti).

Medorippe lanata (Linnaeus, 1767)

1767 – *Dorippe lanata* Linnaeus; p. 1044
1863 – *Dorippe lanata* Linnaeus *in* Heller; p. 138, Pl. 4 (fig. 9)
1914 – *Dorippe lanata* Linnaeus *in* M. Gemmellaro; p. 78, Pl. 1 (fig. 5)
1929 – *Dorippe lanata* Linnaeus *in* Glaessner; p. 137
2004 – *Medorippe lanata* (Linnaeus) *in* Garassino, De Angeli, Gallo & Pasini; p. 262

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported some specimens, housed in Marchese di Monterosato's collection (repository and catalogue number unknown).

†Family Orithopsidae Schweitzer, Feldmann, Fam, Hessin, Hetrick, Nyborg & Ross, 2003

Cherpiocarcinus Marangon & De Angeli, 1997

Type species: *Cherpiocarcinus rostratus* Marangon & De Angeli, 1997.
Stratigraphic range: lower Oligocene (Rupelian).

Cherpiocarcinus rostratus Marangon & De Angeli, 1997

1997 – *Cherpiocarcinus rostratus* Marangon & De Angeli; p. 102, Text-fig. 2, Pl. 1 (figs. 1-2)
2003a – *Cherpiocarcinus rostratus* Marangon & De Angeli *in* De Angeli & Marangon; p. 103, Text-fig. 1 (1)
2003 – *Cherpiocarcinus rostratus* Marangon & De Angeli *in* Schweitzer, Feldmann, Fam, Hessin, Hetrick, Nyborg & Ross; p. 39, Pl. 13 (fig. 1)

Holotype: MCZ 1548 (I.G. 284620).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte.
Material: Marangon & De Angeli (1997) reported two specimens (MCZ 1548, 1549) from Case Cherpione (Alessandria).

Superfamily Calappoidea A. Milne Edwards, 1837
Family Calappidae A. Milne Edwards, 1837

Bittnerilia De Angeli & Garassino, 2003

Type species: *Lambrus eocaenus* Bittner, 1883.
Stratigraphic range: middle Eocene (Lutetian).

Bittnerilia dentata Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Bittnerilia dentata* Beschin, De Angeli, Checchi & Zarantonello; p. 17, Text-fig. 11, Pl. 3 (fig. 7 a-b)

Holotype: MCZ 2298 (I.G. 296517).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported two specimens (MCZ 2298, 2319) from Grola di Cornedo Vicentino (Vicenza).

Bittnerilia eocaena (Bittner, 1883)

1883 – *Lambrus eocaenus* Bittner; p. 309, Pl. 1 (fig. 7 a-c)
1910a – *Lambrus eocaenus* Bittner *in* Fabiani; p. 28
1915 – *Lambrus eocaenus* Bittner *in* Fabiani; p. 284
1983 – *Parthenope eocaena* (Bittner) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 62, Pl. 2 (fig. 3 a-b)
1994 – *Parthenope eocaena* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 181, Pl. 6 (fig. 1 a-b)
2001 – *Parthenope eocaena* (Bittner) *in* De Angeli & Beschin; p. 27
2003 – *Bittnerilia eocaena* (Bittner) *in* De Angeli & Garassino; p. 17, Text-figs. 2-4
2004 – *Bittnerilia eocaena* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Bittnerilia eocaena* (Bittner) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 18

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1883) reported one specimen from S. Giovanni Ilarione (Verona) (repository and catalogue number unknown); Busulini *et al.* (1983) reported one specimen (*18) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported three specimens (MCZ1289, 1290, 1293) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); De Angeli & Garassino (2003) reported one specimen (MCZ 2387) from "Albanello" quarry of Nogarole Vicentino (Vicenza).

Calappa Weber, 1795

Type species: *Cancer granulatus* Linnaeus, 1758.
Stratigraphic range: ?middle Eocene – Recent.

Calappa granulata (Linnaeus, 1758)

1758 – *Cancer granulatus* Linnaeus; p. 627
1767 – *Cancer granulatus* Linnaeus; p. 533
1798 – *Calappa granulata* (Linnaeus) *in* Fabricius; p. 346
1816 – *Calappa granulata* (Linnaeus) *in* Risso; p. 18
1825 – *Calappa granulata* (Linnaeus) *in* Desmarest; p. 109, Pl. 10 (fig. 1)
1828 – *Calappa granulata* (Linnaeus) *in* Roux; Pl. 2 (fig. 13), Pl. 16 (figs. 1-7)
1861 – *Calappa granulata* (Linnaeus) *in* A. Milne Edwards; p. 88
1863 – *Calappa granulata* (Linnaeus) *in* Heller; p. 130, Pl. 4 (fig. 3)
1914 – *Calappa granulata* (Linnaeus) *in* M. Gemmellaro; p. 80, Pl. 1 (figs. 9-10)

1918 – *Calappa granulata* (Linnaeus) *in* Pesta; Text-fig. 97
1929 – *Calappa granulata* (Linnaeus) *in* Glaessner; p. 70
1936 – *Calappa granulata* (Linnaeus) *in* Nobre; p. 81, Pl. 28 (figs. 73-74)
1940 – *Calappa granulata* (Linnaeus) *in* Bouvier; p. 203, Text-fig. 203, Pl. 7 (fig. 1)
1946 – *Calappa granulata* (Linnaeus) *in* Zariquiey Alvarez; p. 143, Text-fig. 163
1965 – *Calappa granulata* (Linnaeus) *in* Forest; p. 362
1968 – *Calappa granulata* (Linnaeus) *in* Zariquiey Alvarez; p. 315, Text-figs. 105 c, 107 a
1992 – *Calappa granulata* (Linnaeus) *in* Falciai & Minervini; p. 181, Pl. 12 (fig. 4)
2004a – *Calappa granulata* (Linnaeus) *in* Garassino & De Angeli; p. 38, Text-fig. 4 (1-3)
2004 – *Calappa granulata* (Linnaeus) *in* Garassino, De Angeli, Gallo & Pasini; p. 264, Text-fig. 7 a-c

Holotype: lost.
Stratigraphic range: Pliocene – Pleistocene.
Occurrence: Piemonte, Emilia Romagna, Sicilia.
Material: M. Gemmellaro (1914) reported two specimens from Monte Pellegrino and Altavilla (Palermo), the first housed in Marchese di Monterosato's collection (repository unknown) and the second in MGUP (catalogue number unknown); Garassino & De Angeli (2004a) reported three specimens (MG from 0609 to 0611) from Fiume Arda (Piacenza); Garassino *et al.* (2004) reported 14 specimens (PU from 41150 to 41163) from Candelo, Masserano and Cossato (Biella).

Calappa sp.

1891a – *Calappa* sp. *in* Ristori; p. 9, Pl. 1 (figs. 10, 15)
1891b – *Calappa* sp. *in* Ristori; p. 21
1929 – *Calappa* sp. *in* Glaessner; p. 72

Stratigraphic range: Pliocene.
Occurrence: Toscana, Lazio.
Material: Ristori (1891a) reported two specimens from Orciano (Pisa), today lost; Ristori (1891b) reported many specimens from Monte Mario (Roma), belonging to Zuccari's collection (repository and catalogue number unknown).

Calappa sp.

1895 – *Calappa* sp. *in* Crema; p. 673, Text-fig. 13
1929 – *Calappa* sp. *in* Glaessner; p. 71

Stratigraphic range: Miocene – Pliocene.
Occurrence: Piemonte.
Material: Crema (1895) reported some specimens from Torino, Sciolze, Baldissero (Torino), and Pino d'Asti (Asti), today lost.

Calappa sp.

1896 – *Calappa* sp. *in* Ristori; p. 507, Pl. 12 (fig. 11)
1909 – *Calappa* sp. *in* Lörenthey; p. 235, Pl. 2 (fig. 7)
1929 – *Calappa* sp. *in* Glaessner; p. 72
1950 – *Calappa* sp. *in* Comaschi Caria; p. 326
1956 – *Calappa* sp. *in* Comaschi Caria; p. 288

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Ristori (1896) reported one specimen from S. Guglielmo (Cagliari), today lost; Lörenthey (1909) reported some specimens from Cadreas (Sassari) and Monte S. Michele (Cagliari), belonging to Lovisato' collection (repository and catalogue number unknown).

Calappa sp.

1909 – *Calappa* sp. *in* Lörenthey; p. 236

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported some specimens from Nurri, Monte S. Michele, Bonorva and S. Avendrace (Cagliari) (repository and catalogue number unknown).

Calappa sp.

1987 – *Calappa* sp. *in* Allasinaz; p. 521, Text-fig. 4, Pl. 1 (fig. 1)

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte.
Material: Allasinaz (1987) reported one specimen (MCSN 256) from Fontanino di Rio Caramagna (Cassinelle).

Calappa? sp.

1907 – *Calappa*? sp. *in* Lörenthey; p. 82, Pl. 4 (fig. 8)
1909 – *Calappa* sp. *in* Lörenthey; p. 236, Pl. 2 (fig. 8)

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported some specimens from S. Avendrace (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Calappa spec.

1875 – *Calappa* spec. *in* Bittner; p. 74, Pl. 1 (fig. 7 a-b)
1929 – *Calappa* sp. Bittner *in* Glaessner; p. 72
2001 – *Calappa* spec. Bittner *in* De Angeli & Beschin; p. 22

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875) reported one specimen from S. Giovanni Ilarione (Verona) (repository and catalogue number unknown).

Calappilia A. Milne Edwards, 1873

Type species: *Calappilia verrucosa* A. Milne Edwards, 1873.
Stratigraphic range: Eocene – Recent.

Calappilia dacica Bittner, 1893

1893 – *Calappilia dacica* Bittner; p. 16, Pl. 2 (fig. 1)
1898 – *Calappilia dacica* Bittner *in* Lörenthey; p. 30, Pl. 1 (fig. 5)
1929 – *Calappilia dacica* Bittner *in* Glaessner; p. 73

1929 – *Calappilia dacica* Bittner *in* Lörenthey & Beurlen; p. 127, Pl. 6 (figs. 4-6)
1982 – *Calappilia dacica* Bittner *in* Busulini, Tessier & Visentin; p. 77
2001 – *Calappilia dacica* Bittner *in* De Angeli & Beschin; p. 22
2004 – *Calappilia dacica* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1982) reported two specimens from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Calappilia gemmata Beschin, Busulini, De Angeli & Tessier, 1994

1994 – *Calappilia gemmata* Beschin Busulini, De Angeli & Tessier; p. 167, Text-fig. 3, Pl. 2 (figs. 1-2)
2001 – *Calappilia gemmata* Beschin Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 22

Holotype: MCZ 1427 (I.G. 284616).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported four specimens (MCZ from 1425 to 1428) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Calappilia incisa Bittner, 1886

1886 – *Calappilia incisa* Bittner; p. 48, Text-fig. 3 a-c
1910a – *Calappilia incisa* Bittner *in* Fabiani; p. 6
1915 – *Calappilia incisa* Bittner *in* Fabiani; p. 284
1929 – *Calappilia incisa* Bittner *in* Glaessner; p. 73
1982 – *Calappilia* cfr. *incisa* Bittner *in* Busulini, Tessier & Visentin; p. 77
1994 – *Calappilia incisa* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 168, Pl. 1 (figs. 5-6)
2001 – *Calappilia incisa* Bittner *in* De Angeli & Beschin; p. 22
2004 – *Calappilia* cfr. *incisa* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1886) reported one specimen from "Scole" quarry (Verona) (repository and catalogue number unknown); Busulini *et al.* (1982) reported two specimens from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1994) reported two specimens (MCZ 1259, 1446) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Calappilia mainii Allasinaz, 1987

1987 – *Calappilia mainii* Allasinaz; p. 523, Text-fig. 5, Pl. 1 (figs. 2-6)

Holotype: MCSN 158 M.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte.
Material: Allasinaz (1987) reported five specimens (MCSN 158 M, 1a, 189, 289, 162 M) from Ciglione (Alessandria).

Calappilia subovata Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Calappilia subovata* Beschin, Busulini, De Angeli & Tessier; p. 13, Text-fig. 8, Pl. 2 (fig. 4)
2004 – *Calappilia subovata* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MCZ 2269 (I.G. 296397).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported one specimen (MCZ 2269) from "Main" quarry of Arzignano (Vicenza).

Calappilia verrucosa A. Milne Edwards, 1873

1873 – *Calappilia verrucosa* A. Milne Edwards; p. 8, Pl. 4 (figs. 3, 3a)
2003a – *Calappilia verrucosa* A. Milne Edwards *in* De Angeli & Marangon; p. 101, Text-fig. 1 (2)
2003b – *Calappilia verrucosa* A. Milne Edwards *in* De Angeli & Marangon; p. 190, Text-figs. 3-5

Holotype: MNHN R03771 (cast).
Stratigraphic range: lower Eocene (Ypresian).
Occurrence: Piemonte.
Material: De Angeli & Marangon (2003 a, b) reported two specimens (MCZ 2388, 2389) from Case Cherpione (Alessandria).
Note: this species is also reported from the Oligocene of France.

Calappilia vicetina Fabiani, 1910

1910a – *Calappilia vicetina* Fabiani; p. 4, 21, Pl. 1 (fig. 1 a-c)
1915 – *Calappilia vicetina* Fabiani *in* Fabiani; p. 285
1929 – *Calappilia vicentina* Fabiani *in* Glaessner; p. 74
1987 – *Calappilia vicetina* Fabiani *in* Allasinaz; p. 525, Text-fig. 6, Pl. 1 (fig. 7)
2001 – *Calappilia vicetina* Fabiani *in* De Angeli & Beschin; p. 23

Holotype: MGPD 23999.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte, Veneto.
Material: Fabiani (1910a) reported two specimens (MGPD 23999, same catalogue number for the two specimens) from Case Maraschin di Nanto and Case Soghe (Monti Berici); Allasinaz (1987) reported two specimens (MCSN 236; PU 10) from Ponzone (Acqui).

Calappilia sp.

1997 – *Calappa heberti* Brocchi *in* Vicariotto; p. 28, Text-fig. 2 a-d
2000 – *Calappilia* sp. *in* De Angeli & Franchi; p. 20
2001 – *Calappilia* sp. *in* De Angeli & Beschin; p. 23

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Vicariotto (1997) reported one specimen

(MCZ 1575) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Mursiopsis Ristori, 1889

Type species: *Mursiopsis pustulosus* Ristori, 1889.
Stratigraphic range: lower Oligocene (Rupelian).

Mursiopsis pustulosus Ristori, 1889

1889 – *Mursiopsis pustulosus* Ristori; p. 405, Pl. 15 (figs. 6-8)
1929 – *Mursiopsis pustulosus* Ristori *in* Glaessner; p. 261
1969 – *Mursiopsis pustulosus* Ristori *in* Glaessner; p. 495
1974 – *Mursiopsis pustulosus* Ristori *in* Mastrorilli; p. 4
1987 – *Mursiopsis pustulosus* Ristori *in* Allasinaz; p. 527, Text-fig. 7, Pl. 1 (figs. 8-9)

Holotype: lost.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte, Liguria.
Material: Ristori (1889) reported one specimen from Sassello (Savona), housed in don Perrando's collection, today lost; Allasinaz (1987) reported three specimens (MCSN 361, 223, 101M), from Ciglione and Ponzone (Acqui).

Mursiopsis sp.

1909 – *Mursiopsis* sp. *in* Lörenthey; p. 236

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported one specimen from Monte della Pace (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Family Hepatidae Stimpson, 1871

Hepatiscus Bittner, 1875

Type species: *Hepatiscus neumayri* Bittner, 1875.
Stratigraphic range: Eocene.

?Hepatiscus distefanoi Checchia-Rispoli, 1905

1905 – *Hepatiscus distefanoi* Checchia-Rispoli; p. 323, Pl. 1 (figs. 9, 11-13)
1929 – *Hepatiscus distefanoi* Checchia-Rispoli *in* Glaessner; p. 209
1969 – *Hepatiscus? distefanoi* Checchia-Rispoli *in* Via Boada; p. 384

Holotype: MGUP.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1905) reported one specimen from Pachino (Siracusa) (MGUP, catalogue number unknown).
Note: Via Boada (1969) ascribed this species to the family Leucosiidae.

Hepatiscus minimus Beschin, Busulini, De Angeli & Tessier, 1994

1994 – *Hepatiscus minimus* Beschin, Busulini, De Angeli & Tessier; p. 169, Text-fig. 4, Pl. 2 (figs. 4-5)
1999 – *Hepatiscus minimus* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 13, Text-fig. 2 (5), Pl. 2 (fig. 6)
2001 – *Hepatiscus minimus* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 23

Holotype: MCZ 1429 (I.G. 284490).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported six specimens (MCZ 1429, 1439, 1344, 1456, 1458, 1459) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Hepatiscus neumayri Bittner, 1875

1875 – *Hepatiscus neumayri* Bittner; p. 75, Pl. 1 (fig. 8)
1883 – *Hepatiscus neumayri* Bittner *in* Bittner; p. 312, Pl. 1 (fig. 9)
1905 – *Hepatiscus neumayri* Bittner *in* Checchia-Rispoli; p. 324
1910a – *Hepatiscus neumayri* Bittner *in* Fabiani; p. 35, Pl. 1 (fig. 9)
1915 – *Hepatiscus Neumayri* Bittner *in* Fabiani; p. 284
1933 – *Hepatiscus neumayri* Bittner *in* Di Salvo; p. 17
1982 – *Hepatiscus neumayri* Bittner *in* Busulini, Tessier & Visentin; p. 81
1983 – *Hepatiscus neumayri* Bittner *in* Busulini, Tessier, Beschin, Visentin, De Angeli & Rossi; Pl. 3 (fig. 2)
1994 – *Hepatiscus neumayri* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 169, Pl. 2 (fig. 6)
1999 – *Hepatiscus neumayri* Bittner *in* De Angeli & Beschin; p. 14 Text-fig. 2 (2, 3, 4), Pl. 1 (figs. 5 a-b, 6)
2001 – *Hepatiscus neumayri* Bittner *in* De Angeli & Beschin; p. 23, Text-fig. 16
2004 – *Hepatiscus neumayri* Bittner *in* Beschin & De Angeli; p. 21
2004 – Hepatiscus neumayri Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Hepatiscus neumayri* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 18, Pl. 3 (fig. 4)

Holotype: MNHB MB.A. 658.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto, Sicilia.
Material: Bittner (1875, 1883) reported one specimen (MNHB MB.A. 658) from Ciupio (Verona); Fabiani (1910a) reported two specimes (MGPD 11685, 11686) from Ciupio and Buca del Prete (Verona); Di Salvo (1933) reported one specimen from Ponte di Castronuovo (Palermo) (MGUP, catalogue number unknown); Busulini *et al.* (1982) reported six specimens from "Main" quarry of Arzignano (Vicenza), (repository and catalogue number unknown); Beschin *et al.* (1994) reported one specimen (MCZ 1211) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); De Angeli & Beschin (1999) reported 24 specimens (MCZ 1172, 1173, 1211, 1278, 1294, 1340, from 1625 to 1643) from Ciupio (Verona), and "Main" quarry of Arzignano, "Boschetto" and "Albanello" quarries of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported 18 specimens (MCZ 2289, 2290, 2291, 2299, 2307, 2308, 2312, 2313, 2314, 2315, 2336, 2347, 2348, 2349, 2379; MCV 52, 04/12, 04/13) from Grola di Cornedo Vicentino (Vicenza).

Hepatiscus pulchellus Bittner, 1875

1875 – *Hepatiscus pulchellus* Bittner; p. 75, Pl. 1 (figs. 9 a-c, 10)

1905 – *Hepatiscus pulchellus* Bittner *in* Checchia-Rispoli; p. 324
1910a – *Hepatiscus pulchellus* Bittner *in* Fabiani; p. 8, 21, 29, Pl. 1 (figs. 3-4)
1915 – *Hepatiscus pulchellus* Bittner *in* Fabiani; p. 284
1929 – *Hepatiscus pulchellus* Bittner *in* Glaessner; p. 209
1983 – *Hepatiscus pulchellus* Bittner *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 64, Pl. 3 (fig. 5)
1994 – *Hepatiscus pulchellus* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p.171, Pl. 2 (fig. 3)
1999 – *Hepatiscus pulchellus* Bittner *in* De Angeli & Beschin; p. 16, Text-fig. 2 (6), Pl. 1 (figs. 3-4)
2001 – *Hepatiscus pulchellus* Bittner *in* De Angeli & Beschin; p. 23
2004 – *Hepatiscus pulchellus* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Hepatiscus pulchellus* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 19, Pl. 3 (fig. 6)

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875) reported two specimens from Ciupio (Verona) (repository and catalogue number unknown); Fabiani (1910a) reported two specimens (MGPD 11770, 13808) from Ciupio (Verona); Busulini *et al.* (1983) reported three specimens (*30, *17; MSNVE 10094) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported one specimen (MCZ 1267) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); De Angeli & Beschin (1999) reported five specimens (MCZ 1267, from 1644 to 1647) from "Main" quarry of Arzignano (Vicenza), "Boschetto" and "Albanello" quarries of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported four specimens (MCZ 2292, 2350, 2382; MV 53) from Grola di Cornedo Vicentino (Vicenza).
Note: this species is also reported from the middle Eocene (Lutetian) of N Africa.

Hepatiscus sp.

1982 – *Hepatiscus* sp. *in* Busulini, Tessier & Visentin; p. 81

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1982) reported three specimens from "Main" quarry of Arzignano (Vicenza) (SV, catalogue number unknown).

Mainhepatiscus De Angeli & Beschin, 1999

Type species: *Mainhepatiscus zannatoi* De Angeli & Beschin, 1999.
Stratigraphic range: middle Eocene (Lutetian).

Mainhepatiscus zannatoi De Angeli & Beschin, 1999

1999 – *Mainhepatiscus zannatoi* De Angeli & Beschin; p. 18, Text-fig. 2 (8), Pl. 2 (figs. 1-2)
2001 – *Mainhepatiscus zannatoi* De Angeli & Beschin *in* De Angeli & Beschin; p. 24, Text-fig. 17
2004 – *Mainhepatiscus zannatoi* De Angeli & Beschin *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MCZ 1619 (I.G. 284507).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: De Angeli & Beschin (1999) reported three specimens (MCZ 1182, 1619, 1620) from "Main" quarry of Arzignano (Vicenza).

Osachila Stimpson, 1871

Type species: *Osachila tuberosa* Stimpson, 1871.
Stratigraphic range: Eocene – Recent.

Osachila berica De Angeli & Beschin, 1999

1999 – *Osachila berica* De Angeli & Beschin; p. 18, Text-fig. 2 (9), Pl. 2 (figs. 3-4)
2001 – *Osachila berica* De Angeli & Beschin *in* Beschin, De Angeli & Checchi; p. 29
2001 – *Osachila berica* De Angeli & Beschin *in* De Angeli & Beschin; p. 24
2004 – *Osachila berica* De Angeli & Beschin *in* Beschin & De Angeli; p. 21

Holotype: MCZ 1622 (I.G. 284510).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Beschin (1999) reported three specimens (MCZ 1622, 1623, 1624) from Campolongo (Vicenza).

Priabonella Beschin, De Angeli, Checchi & Mietto, 2006

Type species: *Priabonella violatii* Beschin, De Angeli, Checchi & Mietto 2006.
Stratigraphic range: Eocene.

Priabonella violatii Beschin, De Angeli, Checchi & Mietto 2006

1999 – *Hepatiscus poverelli* Via Boada *in* De Angeli & Beschin; p.13, Text-fig. 2 (1), Pl. 1 (figs. 1-2)
2006 – *Priabonella violatii* Beschin, De Angeli, Checchi & Mietto; p. 104, Text-fig. 6, Pl. 2 (figs. 4-6)

Holotype: MCZ 2040.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Beschin (1999) reported 11 specimens (MCZ from 1555 to 1561, from 1615 to 1618) from "Alonte" quarry (Monti Berici, Vicenza), and two specimens (MCZ 1555, 1556) from S. Bovo (Bassano del Grappa) and Val Segato (Vicenza); Beschin *et al.* (2006) reported two specimens (MCZ 2040; MGPD 28739) from Rio Rana and Val Segato (Vicenza).

Pseudohepatiscus Blow & Manning, 1996

Type species: *Pseudohepatiscus marinoi* Blow & Manning, 1996.
Stratigraphic range: Eocene.

Pseudohepatiscus silvanoi De Angeli & Beschin, 1999

1999 – *Pseudohepatiscus silvanoi* De Angeli & Beschin; p. 20, Text-fig. 2 (7), Pl. 2 (fig. 5)

2001 – *Pseudohepatiscus silvanoi* De Angeli & Beschin *in* De Angeli & Beschin; p. 24

Holotype: MCZ 1621 (I.G. 284509).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: De Angeli & Beschin (1999) reported one specimen (MCZ 1621) from "Alvese" quarry (Vicenza).

Superfamily Leucosioidea Samouelle, 1819
Family Leucosiidae Samouelle, 1819

Ebalia Leach, 1817

Type species: *Cancer tuberosus* Pennant, 1777.
Stratigraphic range: Miocene – Recent.

Ebalia cranchii Leach, 1817

1817 – *Ebalia cranchii* Leach; Pl. 25 (figs. 7-11)
1846 – *Ebalia cranchii* Leach *in* Bell; p. 148
1855 – *Ebalia cranchii* Leach *in* Bell; p. 303
1891b – *Ebalia cranchii* var. *romana* Ristori; p. 22, Pl. 1 (figs. 21-23), **nov. syn.**
1892a – *Ebalia cranchii* Leach *in* Ristori; p. 88
1914 – *Ebalia cranchii* var. *romana* Ristori *in* M. Gemmellaro; p. 78, Pl. 1 (figs. 3-6)
1929 – *Ebalia cranchii* var. *romana* Ristori *in* Glaessner; p. 144
1936 – *Ebalia cranchii* Leach *in* Nobre; p. 78, Pl. 26 (fig. 64)
1940 – *Ebalia cranchii* Leach *in* Bouvier; p. 209, Pl. 7 (figs. 7-10)
1946 – *Ebalia cranchii* var. *romana* Ristori *in* Maxia; p. 132, Pl. 1 (fig. 1)
1956 – *Ebalia cranchii* Leach *in* Monod; p. 122, Text-figs. 145-146
1965 – *Ebalia cranchii* Leach *in* Forest; p. 364-371, Text-fig. 25 a-b, Pl. 2 (figs. 1-2)
1968 – *Ebalia cranchii* Leach *in* Zariquiey Alvarez; p. 329, Text-figs. 108 a-b, 111 b, d, 111 A, a, 111 C, b
1981 – *Ebalia cranchii* var. *romana* Ristori *in* Delle Cave; p. 45
1992 – *Ebalia cranchii* Leach *in* Falciai & Minervini; p. 184
2004a – *Ebalia cranchii* Leach *in* Garassino & De Angeli; p. 39, Text-figs. 3 (7, 8), 4 (4), 5, 6

Holotype: unknown.
Stratigraphic range: Pliocene – Pleistocene.
Occurrence: Emilia Romagna, Lazio, Sicilia.
Material: Ristori (1891b) reported some specimens (IGF 991E, syntype) from Farnesina and Monte Mario (Roma), housed in Zuccari's and Clerici's collections, today lost; M. Gemmellaro (1914) reported some specimens from Monte Pellegrino and Ficarazzi (Palermo), housed in Marchese di Monterosato's collection (repository and catalogne number unknown) and in MGUP (catalogue number unknown); Maxia (1946) reported one specimen from Monte Mario (Roma), housed in Clerici's collection (MGPUR, catalogue number unknown); Garassino & De Angeli (2004a) reported 14 specimens (MG from 0604 to 0608, from 0622 to 0630, 0648) from Fiume Arda (Piacenza).

Ebalia fucinii Ristori, 1892

1892a – *Ebalia fucinii* Ristori; p. 88, Text-fig. 2
1929 – *Ebalia fucinii* Ristori *in* Glaessner; p. 144
1981 – *Ebalia fucinii* Ristori *in* Delle Cave; p. 45
2004 – *Ebalia fucinii* Ristori *in* Garassino & De Angeli; p. 40

Holotype: lost.
Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1892a) reported one specimen from Spicchio (Empoli), housed in Fucini's collection, today lost.

Ebalia lamarmorai Lörenthey, 1909

1909 – *Ebalia lamarmorai* Lörenthey; p. 232, Pl. 1 (figs. 2-3 a-b)

Holotype: unknown.
Stratigraphic range: middle Miocene (Langhian).
Occurrence: Sardegna.
Material: Lörenthey (1909) reported two specimens from Monte S. Michele (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Ebalia tuberosa Pennant, 1777

1777 – *Cancer tuberosus* Pennant; Pl. 19 a (fig. 19)
1817 – *Ebalia pennanti* Leach; Pl. 25 (figs. 1-6), **nov. syn.**
1891b – *Ebalia pennantii* Leach *in* Ristori; p. 21, Pl. 1 (figs. 24-25)
1893 – *Ebalia pennanti* Leach *in* Ristori; p. 88
1897 – *Ebalia pennanti* Leach *in* Bell; p. 3
1914 – *Ebalia pennanti* Leach *in* M. Gemmellaro; p. 79, Pl. 1 (figs. 7-8)
1918 – *Ebalia tuberosa* (Pennant) *in* Pesta; p. 297, Text-fig. 91
1921 – *Ebalia pennanti* Leach *in* Bell; p. 8
1929 – *Ebalia pennanti* Leach *in* Glaessner; p. 145
1940 – *Ebalia tuberosa* (Pennant) *in* Ferrer Galdiano; p. 76, Text-figs. 3-6
1940 – *Ebalia tuberosa* (Pennant) *in* Bouvier; p. 207, 211, Pl. 7 (figs. 21-25)
1946 – *Ebalia tuberosa* (Pennant) *in* Zariquiey Alvarez; p. 147, Text-fig. 164 a, Pl. 10 (b)
1956 – *Ebalia tuberosa* (Pennant) *in* Monod; p. 124, Text-figs. 150-151
1965 – *Ebalia tuberosa* (Pennant) *in* Forest; p. 370
1968 – *Ebalia tuberosa* (Pennant) *in* Zariquiey Alvarez; p. 326, Text-figs. 109 d, 110 a-c, 111 a
1992 – *Ebalia tuberosa* (Pennant) *in* Falciai & Minervini; p. 184, 185
2004a – *Ebalia tuberosa* (Pennant) *in* Garassino & De Angeli; p. 40

Holotype: unknown.
Stratigraphic range: Pliocene – Pleistocene.
Occurrence: Lazio, Sicilia.
Material: Ristori (1891b) reported some specimens from Farnesina and Monte Mario (Roma), housed in Zuccari's collection (MGPUR, catalogue number unknown); M. Gemmellaro (1914) reported one specimen from Ficarazzi (Palermo), housed in Marchese di Monterosato's collection (repository and catalogue number unknown).

Hepatinulus Ristori, 1886

Type species: *Hepatinulus seguentiae* Ristori, 1886.
Stratigraphic range: Miocene – Pliocene.

Hepatinulus lovisatoi Lörenthey, 1909

1909 – *Hepatinulus lovisatoi* Lörenthey; p. 230, Pl. 1 (fig. 8)

1929 – *Hepatinulus lovisatoi* Lörenthey *in* Glaessner; p. 209

Holotype: unknown.
Stratigraphic range: lower Miocene (Burdigalian).
Occurrence: Sardegna.
Material: Lörenthey (1909) reported one specimen from Cugia (Sassari), housed in Lovisato's collection (repository and catalogue number unknown).

Hepatinulus seguentiae Ristori, 1886

1886 – *Hepatinulus seguentiae* Ristori; p. 121, Pl. 3 (figs. 6-7)
1929 – *Hepatinulus seguentiae* Ristori *in* Glaessner; p. 209

Holotype: unknown.
Stratigraphic range: Pliocene.
Occurrence: Sicilia.
Material: Ristori (1886) reported two specimens from Scoppo and S. Filippo (Trapani) (repository and catalogue number unknown).

Ilia Leach, 1817

Type species: *Cancer nucleus* Linnaeus, 1758.
Stratigraphic range: ?Eocene – Recent.

Ilia cfr. *I. nucleus* (Linnaeus, 1758)

1891b – *Ilia* cfr. *nucleus* (Linnaeus) *in* Ristori; p. 23
1929 – *Ilia* cfr. *nucleus* (Linnaeus) *in* Glaessner; p. 225

Stratigraphic range: Pliocene.
Occurrence: Lazio.
Material: Ristori (1891b) reported three specimens from Monte Mario (Roma) (Zuccari's collection) (repository and catalogue number unknown).

Ilia pliocaenica Ristori, 1891

1891a – *Ilia pliocaenica* Ristori; p. 10, Pl. 1 (figs. 8-9, 11-12, 14)
1892a – *Ilia pliocaenica* Ristori *in* Ristori; p. 86
1929 – *Ilia pliocaenica* Ristori *in* Glaessner; p. 225
1981 – *Ilia pliocaenica* Ristori *in* Delle Cave; p. 45
2004a – *Ilia pliocaenica* Ristori *in* Garassino & De Angeli; p. 40, Text-fig. 4 (5)
2004 – *Ilia pliocaenica* Ristori *in* Garassino, De Angeli, Gallo & Pasini; p. 266, Text-fig. 8 a-b

Syntype: IGF 939E.
Stratigraphic range: Pliocene – Pleistocene.
Occurrence: Piemonte, Emilia Romagna, Toscana.
Material: Ristori (1891a) reported some specimens from Spicchio (Empoli) (IGF); Garassino & De Angeli (2004a) reported five specimens (MG from 0636 to 0639, 0647) from Fiume Arda (Piacenza); Garassino *et al.* (2004) reported six specimens (PU from 41164 41169) from Masserano and Cossato (Biella).

Nucilobus Morris & Collins, 1991

Type species: *Nucilobus symmetricus* Morris & Collins, 1991.
Stratigraphic range: upper Eocene – Neogene.

Nucilobus bericus De Angeli & Beschin, 2004

2004 – *Nucilobus bericus* De Angeli & Beschin; p. 120, Text-figs. 2-3

Holotype: MCZ 2395 (I.G. 296613).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Beschin (2004) reported one specimen (MCZ 2395) from Lonigo (Vicenza).

Palaeomyra A. Milne Edwards *in* E. Sismonda, 1861

Type species: *Palaeomyra bispinosa* A. Milne Edwards *in* E. Sismonda, 1861.
Stratigraphic range: Oligocene – Miocene.

Palaeomyra bispinosa A. Milne Edwards *in* E. Sismonda, 1861

1861 – *Palaeomyra bispinosa* A. Milne Edwards *in* E. Sismonda; p. 16, Text-figs. 18-20
1969 – *Palaeomyra bispinosa* A. Milne Edwards *in* Glaessner; p. R498
2004 – *Palaeomyra bispinosa* A. Milne Edwards *in* Garassino, De Angeli, Gallo & Pasini; p. 267, Text-figs. 9-10 a-b

Holotype: lost.
Stratigraphic range: Oligocene – Miocene.
Occurrence: Piemonte.
Material: E. Sismonda (1861) reported one specimen from Torino, today lost; Garassino *et al.* (2004) reported six specimens (PU from 41170 to 41175) from Cocconato (Asti) and Morbello (Alessandria).

Typilobus Stoliczka, 1871

Type species: *Typilobus granulosus* Stoliczka, 1871.
Stratigraphic range: Eocene – Miocene.

Typilobus semseyanus Lörenthey, 1897

1897 – *Typilobus semseyanus* Lörenthey; p. 97
1898 – *Typilobus semseyanus* Lörenthey *in* Lörenthey; p. 27, Pl. 1 (figs. 3-4)
1929 – *Typilobus semseyanus* Lörenthey *in* Lörenthey & Beurlen; p. 125, Pl. 4 (figs. 10-11)
1998 – *Typilobus semseyanus* Lörenthey *in* Beschin, Busulini, De Angeli & Ungaro; p. 17, Text-fig. 6 (4)
2000 – *Typilobus semseyanus* Lörenthey *in* Beschin, De Angeli & Alberti; p. 15

Holotype: unknown
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (1998) reported one specimen (MCZ 1485) from "Rossi" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Superfamily Majoidea Samouelle, 1819
Family Majidae Samouelle, 1819

Maja Lamarck, 1801

Type species: *Cancer squinado* Herbst, 1788.
Stratigraphic range: Miocene – Recent.

Maja miocaenica Lörenthey, 1907

1907 – *Maja miocaenica* Lörenthey; p. 83, Pl. 3 (figs. 1, 10)
1909 – *Maja miocaenica* Lörenthey *in* Lörenthey; p. 237, Pl. 1 (figs. 1 a-b, 10 a-f)
1929 – *Maja miocaenica* Lörenthey *in* Glaessner; p. 247
1990 – *Maja miocaenica* Lörenthey *in* Moissette & Müller; p. 739, Pl. 1 (fig. 2)

Holotype: unknown.
Stratigraphic range: upper Miocene (Tortonian).
Occurrence: Sardegna.
Material: Lörenthey (1907) reported two specimens from Capo S. Marco (Oristano), housed in Lovisato's collection (repository and catalogue number unknown).
Note: this species is also reported from the upper Miocene of Oranie (Algérie) and Malta.

Maja squinado (Herbst, 1788)

1788 – *Cancer squinado* Herbst; p. 214, Pl. 14 (figs. 84-85)
1816 – *Maja squinado* (Herbst) *in* Risso; p. 44
1817 – *Maja squinado* (Herbst) *in* Leach; p. 1817, Pl. 18 (figs. 1-6)
1825 – *Maja squinado* (Herbst) *in* Desmarest; p. 145
1857 – *Maja squinado* (Herbst) *in* Meneghini; p. 557
1861 – *Maja squinado* (Herbst) *in* A. Milne Edwards; p. 88
1863 – *Maja squinado* (Herbst) *in* Heller; p. 49, Pl. 1 (figs. 17-24)
1871 – *Maja squinado* (Herbst) *in* Woodward; p. 130
1855 – *Maja squinado* (Herbst) *in* Carus; p. 507
1890 – *Maja squinado* (Herbst) *in* Reid; p. 281
1891b – *Pseudocarcinus*? Ristori; p. 20, Pl. 1 (fig. 29), **nov syn.**
1897 – *Maja squinado* (Herbst) *in* Bell; p. 3
1903 – *Maja squinado* (Herbst) *in* Checchia-Rispoli; p. 488
1909 – *Maja squinado* (Herbst) *in* Lörenthey; p. 238
1911 – *Maja squinado* (Herbst) *in* Magrì; p. 8
1914 – *Maja squinado* (Herbst) *in* M. Gemmellaro; p. 81, Pl. 1 (figs. 11-12)
1914 – *Maja squinado* var. *di-stefanoi* M. Gemmellaro; p. 83, Pl. 1 (figs. 13-14), **nov. syn.**
1918 – *Maja squinado* (Herbst) *in* Pesta; p. 361, Text-fig. 116
1929 – *Maja squinado* (Herbst) *in* Glaessner; p. 247
1929 – *Maja squinado* (Herbst) *in* Santucci; p. 63
1931 – *Maja squinado* (Herbst) *in* Nobre; p. 142, Text-fig. 82
1940 – *Maja squinado* (Herbst) *in* Bouvier; p. 321, Text-fig. 95
1946 – *Maja squinado* (Herbst) *in* Zariquiey Alvarez; p. 169, Text-fig. 171
1951 – *Maja squinado* (Herbst) *in* Capart; p. 98, Text-fig. 32
1956 – *Maja squinado* (Herbst) *in* Monod; p. 474, Text-figs. 638-643
1961 – *Maja squinado* (Herbst) *in* Luther & Fiedler; p. 117, 166
1966 – *Maja squinado* (Herbst) *in* Bauchau; p. 79
1968 – *Maja squinado* (Herbst) *in* Zariquiey Alvarez; p. 446, Text-figs. 149 a, 150 g, h
1980 – *Maja squinado* (Herbst) *in* Ingle; p. 23, 45, 141
1981 – *Maja squinado* (Herbst) *in* Varola; p. 13, Pl. 3 (fig. 1)
1992 – *Maja squinado* (Herbst) *in* Falciai & Minervini; p. 247, Pl. 17 (fig. 2)
2004a – *Maja squinado* (Herbst) *in* Garassino & De Angeli; p. 40, Text-fig. 7

Holotype: unknown.
Stratigraphic range: Pliocene – Pleistocene.
Occurrence: Emilia Romagna, Lazio, Puglia, Sicilia, Sardegna.
Material: Meneghini (1857) reported some specimens from Alghero (repository and catalogue number unknown); Ristori (1891b) reported three specimens from Monte Mario and Farnesina (Roma) (repository and catalogue number unknown); M. Gemmellaro (1914) reported one specimen from Monte Pellegrino (Palermo) (MGUP, catalogue number unknown); Varola (1981) reported one specimen from Rocca Vecchia (Lecce) (GNSL, catalogue number unknown); Garassino & De Angeli (2004a) reported one specimen (MG 0603) from Fiume Arda (Piacenza).

Maja sp.

1981 – *Maja* sp. *in* Varola; p. 14, Pl. 3 (figs. 2-4)

Stratigraphic range: Pliocene.
Occurrence: Puglia.
Material: Varola (1981) reported three specimens from Leuca (Lecce) (GNSL, catalogue number unknown).

Micromaia Bittner, 1875

Type species: *Micromaia tuberculata* Bittner, 1875.
Stratigraphic range: middle Eocene – lower Oligocene.

Micromaia elegans Beschin, Busulini, De Angeli & Tessier, 1985

1985 – *Micromaia elegans* Beschin, Busulini, De Angeli & Tessier; p. 102, Text-figs. 3 (7), 4 (4), Pl. 2 (figs. 1 a-c, 2)
2001 – *Micromaia elegans* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 26, Text-fig. 18 (6)
2002 – *Micromaia elegans* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 14, Text-fig. 9, Pl. 3 (fig. 3)
2004 – *Micromaia elegans* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MSNVE 10482.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1985) reported three specimens (*197, *198; MSNVE 10482) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2002) reported one specimen (MCZ 2270) from "Main" quarry of Arzignano (Vicenza).

Micromaia mainensis Beschin, Busulini, De Angeli & Tessier, 1985

1985 – *Micromaia mainensis* Beschin, Busulini, De Angeli & Tessier; p. 104, Text-figs. 3 (4), 4 (2), Pl. 3 (figs. 1-3)
2001 – *Micromaia mainensis* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 26, Text-fig. 18 (4)

2004 – *Micromaia mainensis* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Micromaia mainensis* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 20, Pl. 4 (fig. 2)

Holotype: MSNVE 10843.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1985) reported 19 specimens (*98, *101, *102, * 104, *105, *106, *116, *117, *118, *119, *191, *192, *193, *194, *195, *196, *214, *264; MSNVE 10483) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported eight specimens (MCZ from 2294 to 2297, 2337, 2386; MV 49, 04/16) from Grola di Cornedo Vicentino (Vicenza).

Micromaia margaritata Fabiani, 1910

1910a – *Micromaja margaritata* Fabiani; p. 10, Pl. 2 (fig. 2)
1915 – *Micromaya margaritata* Fabiani *in* Fabiani; p. 284
1929 – *Micromaia margaritata* Fabiani *in* Glaessner; p. 256
1982 – *Micromaia margaritata* Fabiani *in* Busulini, Tessier & Visentin; p. 79
1985 – *Micromaia margaritata* Fabiani *in* Beschin, Busulini, De Angeli & Tessier; p. 106, Text-fig. 3 (3), Pl. 1 (figs. 3-4)
1994 – *Micromaia margaritata* Fabiani *in* Beschin, Busulini, De Angeli & Tessier; p. 179, Pl. 5 (fig. 3)
2001 – *Micromaia margaritata* Fabiani *in* De Angeli & Beschin; p. 26, Text-fig. 18 (3)
2004 – *Micromaia margaritata* Fabiani *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Micromaia margaritata* Fabiani *in* Beschin, De Angeli, Checchi & Zarantonello; p. 21, Pl. 4 (fig. 3)

Holotype: MGPD 11687.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Vicenza.
Material: Fabiani (1910a) reported one specimen (MGPD 11687) from Ciupio (Verona); Busulini *et al.* (1982) reported two specimens from "Main" quarry of Arzignano (Vicenza), (repository and catalogue number unknown); Beschin *et al.* (1985) reported two specimens (*27, *265) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported three specimens (MCZ 1208, 1260, 1449) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2362) from Grola di Cornedo Vicentino (Vicenza).
Note: this species is also reported from the Eocene of Spain.

Micromaia meneguzzoi Beschin, Busulini, De Angeli & Tessier, 1985

1985 – *Micromaia meneguzzoi* Beschin, Busulini, De Angeli & Tessier; p. 107, Text-figs. 3 (5), 4 (3), Pl. 4 (fig. 1 a-e)
2001 – *Micromaia meneguzzoi* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 26, Text-fig. 18 (5)
2004 – *Micromaia meneguzzoi* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MSNVE 10484.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1985) reported one specimen (MSNVE 10484) from "Main" quarry of Arzignano (Vicenza).

Micromaia priabonensis Oppenheim, 1901

1901 – *Micromaja* (?) *priabonensis* Oppenheim; p. 282, Pl. 7 (figs. 13-13b)
1915 – *Micromaya priabonensis* Oppenheim *in* Fabiani; p. 285
1929 – *Micromaia* (?) *priabonensis* Oppenheim *in* Glaessner; p. 257
1962 – *Micromaja* (?) *priabonensis* Oppenheim *in* Piccoli & Mocellin; p. 86
1985 – *Micromaia priabonensis* Oppenheim *in* Beschin, Busulini, De Angeli & Tessier; p. 109, Text-figs. 3-6, Pl. 4 (figs. 2-3)
2001 – *Micromaia priabonensis* Oppenheim *in* De Angeli & Beschin; p. 26
2006 – *Micromaia priabonensis* Oppenheim *in* Beschin, De Angeli, Checchi & Mietto; p. 106, Pl. 2 (fig. 7)

Holotype: unknown
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Oppenheim (1901) reported this species from Priabona (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1985) reported nine specimens (*121, *213, *215, *221, *222, *223, *224, *225, *266) from Priabona and Nanto (Vicenza); Beschin *et al.* (2006) reported ten specimens (MCZ 1160, 1161, 1162, 1238, 1327, 2441, 2442, 2443, 2454, 2455) from Buso della Rana (Vicenza).

Micromaia tuberculata Bittner, 1875

1875 – *Micromaia tuberculata* Bittner; p. 76, Pl. 2 (fig. 2)
1883 – *Micromaja tuberculata* Bittner *in* Bittner; p. 308, Pl. 1 (fig. 6)
1898 – *Micromaia tuberculata* Bittner *in* Lörenthey; p. 31, Pl. 1 (figs. 2-3)
1899 – *Micromaia tuberculata* Bittner *in* Oppenheim; p. 57
1909 – *Micromaia tuberculata* Bittner *in* Lörenthey; p. 123
1910a – *Micromaja tuberculata* Bittner *in* Fabiani; p. 12, 21, Pl. 2 (figs. 3-4)
1915 – *Micromaya tuberculata* Bittner *in* Fabiani; p. 284
1925 – *Micromaia tuberculata* Bittner *in* Schlosser; p. 143
1929 – *Micromaia tuberculata* Bittner *in* Glaessner; p. 257
1929 – *Micromaia tuberculata* Bittner *in* Lörenthey & Beurlen; p. 141, Pl. 7 (figs. 4-5)
1969 – *Micromaia tuberculata* Bittner *in* Via Boada; p. 162, Pl. 11 (figs. 1-4), Pl. 12 (fig. 1)
1981 – *Micromaia tuberculata* Bittner *in* Quayle & Collins; p. 744, Pl. 104 (fig. 15)
1982 – *Micromaia tuberculata* Bittner *in* Busulini, Tessier, Visentin; p. 79
1985 – *Micromaia tuberculata* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 101, Text-figs. 3 (1), 4 (1), Pl. 1, (figs. 1-2)
1994 – *Micromaia tuberculata* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 178, Pl. 5 (figs. 2-4)
2001 – *Micromaia tuberculata* Bittner *in* De Angeli & Beschin; p. 24, Text-figs. 18 (1), 19
2004 – *Micromaia tuberculata* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Micromaia tuberculata* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 20, Pl. 4 (fig. 1)

Holotype: unknown.

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875, 1883) and Fabiani (1910a) reported this species from S. Giovanni Ilarione (Verona) (repository and catalogue number unknown); Busulini *et al.* (1982) reported this species from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1985) reported 26 specimens (*79, *81, *82, *83, *86, *87, *88, *89, *90, *92, *93, *199, *200, *201, *202, *203, *204, *205, *206, *208, *209, *210, *211, *220, *262, *263) from "Main" quarry of Arzignano (Vicenza), "Albanello" quarry of Nogarole Vicentino (Vicenza), Ciupio and Croce Grande (Verona); Beschin *et al.* (1994) reported four specimens (MCZ 1206, 1207, 1277, 1305) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported two specimens (MCZ 2335, 2346) from Grola di Cornedo Vicentino (Vicenza).
Note: this species is also reported from the Eocene of Hungary, Spain, Great Britain, and Egypt.

Micromaia sp.

1985 – *Micromaia* sp. *in* Beschin, Busulini, De Angeli & Tessier; p. 110, Text-fig. 3 (2), Pl. 2 (fig. 3 a-b)
2001 – *Micromaia* sp. *in* Beschin, De Angeli & Checchi; p. 29
2001 – *Micromaia* sp. *in* De Angeli & Beschin; p. 26

Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: Beschin *et al.* (1985) reported one specimen (MSNVE 10485) from Valmarana (Vicenza).

Periacanthus Bittner, 1875

Type species: *Periacanthus horridus* Bittner, 1875.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).

Periacanthus dallagoi Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Periacanthus dallagoi* Beschin, De Angeli, Checchi & Zarantonello; p. 19, Text-fig. 12, Pl. 3 (fig. 8)

Holotype: MCZ 2293 (I.G. 296512).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported three specimens (MCZ 2293, 2320, 2343) from Grola di Cornedo Vicentino (Vicenza).

Periacanthus horridus Bittner, 1875

1875 – *Periacanthus horridus* Bittner; p. 77, Pl. 2 (fig. 1)
1895 – *Periacanthus horridus* Bittner *in* Bittner; p. 250, Pl. 1 (figs. 1-2)
1898 – *Periacanthus horridus* Bittner *in* Lörenthey; p. 34
1899 – *Periacanthus horridus* Bittner *in* Oppenheim; p. 57
1910a – *Periacanthus horridus* Bittner *in* Fabiani; p. 22
1915 – *Periacanthus horridus* Bittner *in* Fabiani; p. 284
1929 – *Periacanthus horridus* Bittner *in* Glaessner; p. 311
1929 – *Periacanthus horridus* Bittner *in* Lörenthey & Beurlen; p. 152, Pl. 7 (fig. 8)
1959 – *Periacanthus horridus* Bittner *in* Via Boada; p. 374
1969 – *Periacanthus horridus* Bittner *in* Via Boada; p. 175, Pl. 12 (fig. 2)
1981 – *Periacanthus horridus* Bittner *in* Quayle & Collins; p. 744, Pl. 104 (fig. 14)
1989 – *Periacanthus horridus* Bittner *in* Solè & Via Boada; p. 31
1982 – *Periacanthus horridus* Bittner *in* Busulini, Tessier & Visentin; p. 78, Text-fig. 2
1994 – *Periacanthus horridus* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 177, Pl. 5 (fig. 1)
1995 – *Periacanthus horridus* Bittner *in* De Angeli; p. 14, Text-fig. 2 (4), Pl. 1 (fig. 5)
2001 – *Periacanthus horridus* Bittner *in* De Angeli & Beschin; p. 26, Text-fig. 20
2004 – *Periacanthus horridus* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Periacanthus horridus* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 20

Holotype: unknown.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Bittner (1875, 1895) reported this species from S. Giovanni Ilariore (Verona) (paratype: MNHB K.110, MB.A. 660); Busulini *et al.* (1982) reported one specimen from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1994) reported three specimens (MCZ 1264, 1416, 1448) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); De Angeli (1995) reported one specimen (MCZ 1495) from "Fontanella" di Grancona (Vicenza).
Note: this species is also reported from the middle/upper Eocene of Spain, Great Britain, and Hungary.

Family Mithracidae Balss, 1929

Micippa Leach, 1817

Type species: *Cancer cristatus* Linnaeus, 1758.
Stratigraphic range: lower Oligocene (Rupelian) – Recent.

Micippa antiqua Beschin, De Angeli & Checchi, 2001

2001 – *Micippa antiqua* Beschin, De Angeli & Checchi; p.18, Text-fig. 5, Pl. 2 (fig. 1 a-b)
2001 – *Micippa antiqua* Beschin, De Angeli & Checchi *in* De Angeli & Beschin; p. 27

Holotype: MCZ 2122 (I.G. 286477).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported one specimen (MCZ 2122) from Castelgomberto (Vicenza).

Mithracia Bell, 1858

Type species: *Mithracia libinoides* Bell, 1858.
Stratigraphic range: lower/middle Eocene (Ypresian – Lutetian).

Mithracia margaritifera Beschin, Busulini, De Angeli & Tessier, 1994

1994 – *Mithracia margaritifera* Beschin, Busulini, De Angeli & Tessier; p.179, Text-fig. 5, Pl. 6 (fig. 2 a-c)
2001 – *Mithracia margaritifera* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 27

Holotype: MCZ 1296 (I.G. 211811).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported two specimens (MCZ 1284, 1296) from "Boschetto" and "Albanello" quarries of Nogarole Vicentino (Vicenza).

Mithracia oppionii Larghi, 2002

1998 – ?*Mithracia* sp. *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 23, Text-figs. 9 (3), 11
2000 – ?*Mithracia* sp. *in* Beschin, De Angeli & Alberti; p. 15
2001 – ?*Mithracia* sp. *in* De Angeli & Beschin; p. 27
2002 – *Mithracia oppionii* Larghi; p. 62, Text-figs. 2-3

Holotype: MCZ 2064 (I.G. 286342).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1998) reported three specimens (MCZ 1524, 1525, 1526) from "Rossi" quarry of Monte di Malo (Vicenza); Larghi (2002) reported one specimen (MCZ 2064) from "Lovara" quarry of Chiampo (Vicenza).

Family Pisidae Dana, 1851

Pisa Leach, 1814

Type species: *Cancer biaculeatus* Montagu, 1813.
Stratigraphic range: Pleistocene – Recent.

Pisa armata (Latreille, 1803)

1803 – *Maja armata* Latreille; p. 98
1815 – *Pisa gibbsi* Leach; Pl. 19 (Figs. 1-4), **nov. syn.**
1914 – *Pisa gibbsi* Leach *in* M. Gemmellaro; p. 84, Pl. 1 (fig. 15)
1918 – *Pisa armata* (Latreille) *in* Pesta; p. 344, Text-figs. 110-111
1929 – *Pisa armata* (Latreille) *in* Glaessner; p. 318
1931 – *Pisa armata* (Latreille) *in* Nobre; p. 155, Text-figs. 91-94
1940 – *Pisa gibbsi* Leach *in* Bouvier; p. 331, Text-fig. 202, Pl. 13 (fig. 5)
1946 – *Pisa gibbsi* Leach *in* Zariquiey Alvarez; p. 170, Pl. 23 (d)
1950 – *Pisa gibbsi* Leach *in* Zariquiey Alvarez; p. 109, Pl. 5 (fig. 2)
1956 – *Pisa gibbsi* Leach *in* Monod; p. 486, Text-fig. 654
1958 – *Pisa armata* (Latreille) *in* Holthuis & Gottlieb; p. 119
1961 – *Pisa gibbsi* Leach *in* Nunes-Ruivo; p. 31
1968 – *Pisa armata* (Latreille) *in* Zariquiey Alvarez; p. 454, Text-figs. 151 d, 152 e, 154 d
1992 – *Pisa armata* (Latreille) *in* Falciai & Minervini; p. 251-252

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported one specimen from Monte Pellegrino (Palermo) (MGUP, catalogue number unknown).

Superfamily Parthenopoidea MacLeay, 1838
Family Dairidae Ng & Rodriguez, 1986

Daira De Haan, 1833

Type species: *Cancer perlatus* Herbst, 1790.
Stratigraphic range: middle Eocene (Lutetian) – Recent.

Daira coronata Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Daira coronata* Beschin, De Angeli, Checchi & Zarantonello; p. 21, Text-fig. 13, Pl. 4 (fig. 6)

Holotype: MCZ 2361 (I.G. 296580).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported one specimen (MCZ 2361) from Grola di Cornedo Vicentino (Vicenza).

Daira depressa (A. Milne Edwards, 1865)

1865 – *Phlyctenodes depressus* A. Milne Edwards; p. 367, Pl. 33 (figs. 2-2 b)
1883 – *Phlyctenodes depressus* A. Milne Edwards *in* Bittner; p. 311
1896 – *Pilumnus* sp. *in* Ristori; p. 506, Pl. 12 (fig. 10)
1905 – *Phlyctenodes depressus* A. Milne Edwards *in* Airaghi; p. 205, Pl. 4 (fig. 3)
1910a – *Phlyctenodes depressus* A. Milne Edwards *in* Fabiani; p. 25
1915 – *Phlyctenodes depressus* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Phlyctenodes depressus* A. Milne Edwards *in* Glaessner; 135
1969 – *Daira depressa* (A. Milne Edwards) *in* Via Boada; p. 373
2001 – *Daira depressa* (A. Milne Edwards) *in* Beschin, De Angeli & Checchi; p. 20, Pl. 2 (figs. 2-4)
2001 – *Daira depressa* (A. Milne Edwards) *in* De Angeli & Beschin; p. 28
2004 – *Daira depressa* (A. Milne Edwards) *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Daira depressa* (A. Milne Edwards) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 21, 22

Holotype: unknown.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: A. Milne Edwards (1862-1865) and Airaghi (1905) reported one specimen from Castelgomberto (Vicenza) (repository and catalogue number unknown); Ristori (1896) reported one specimen from S. Urbano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (2001) reported 22 specimens (MCZ from 2095 to 2116), from Castelgomberto (Vicenza).

Daira eocenica var. *sicula* (Di Salvo, 1933)

1933 – *Phymatocarcinus eocenicus* var. *sicula* Di Salvo; p. 23, Pl. 1 (fig. 5 a-d)

2001 – *Daira eocenica* var. *sicula* (Di Salvo) *in* Beschin, De Angeli & Checchi; p. 20
2005 – *Daira eocenica* var. *sicula* (Di Salvo) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 21, 22

Holotype: MGUP 2592.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported five specimens (MGUP 2592, 2612, 2614, 2615, 2616) from Balzo del Gatto, Bichinello, and La Pietra Lunga (Palermo).

Daira salebrosa Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Daira salebrosa* Beschin, Busulini, De Angeli & Tessier; p. 15, Text-fig. 10, Pl. 2 (figs. 5-6)
2004 – *Daira salebrosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Daira salebrosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 21, 22, Pl. 4 (fig. 5)

Holotype: MCZ 2271 (I.G. 296399).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported three specimens (MCZ2271, 2272, 2273) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported three specimens (MCZ 2304, 2316, 2317) from Grola di Cornedo Vicentino (Vicenza).

Family Daldorfiidae Ng & Rodriguez, 1986

Daldorfia Rathbun, 1904

Type species: *Cancer horridus* Linnaeus, 1754.
Stratigraphic range: Oligocene – Recent.

Daldorfia fabianii Beschin, De Angeli & Checchi, 2001

2001 – *Daldorfia fabianii* Beschin, De Angeli & Checchi; p. 22, Text-fig. 6, Pl. 2 (fig. 5)
2001 – *Daldorfia fabianii* Beschin, De Angeli & Checchi *in* De Angeli & Beschin; p. 28
2004 – *Daldorfia fabianii* Beschin, De Angeli & Checchi *in* Beschin & De Angeli; p. 21

Holotype: MCZ 2118 (I.G. 286473).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported one specimen (MCZ 2118) from Castelgomberto (Vicenza).

Family Parthenopidae MacLeay, 1838

Parthenope Weber 1795

Type species: *Cancer longimanus* Linnaeus, 1758.
Stratigraphic range: Eocene – Recent.

Parthenope angulifrons Latreille, 1825

1825 – *Parthenope angulifrons* Latreille; p. 46
1863 – *Lambrus angulifrons* (Latreille) *in* Heller; p. 57, Pl. 2
1918 – *Lambrus angulifrons* (Latreille) *in* Pesta; p. 371, Text-fig. 119
1931 – *Lambrus angulifrons* (Latreille) *in* Nobre; p. 140, Text-figs. 80-81
1940 – *Lambrus angulifrons* (Latreille) *in* Bouvier; p. 310, Text-fig. 191, Pl. 12 (fig. 1)
1941 – *Lambrus angulifrons* (Latreille) *in* Zariquiey Cenarro; p. 351, 365, Text-figs. 36-44 a-c
1946 – *Lambrus angulifrons* (Latreille) *in* Zariquiey Alvarez; p. 167, Pl. 20
1968 – *Parthenope angulifrons* Latreille *in* Zariquiey Alvarez; p. 439, Text-fig. 148 b
1992 – *Parthenope angulifrons* Latreille *in* Falciai & Minervini; p. 242
2004b – *Parthenope angulifrons* Latreille *in* Garassino & De Angeli; p. 22, Text-figs. 2, 4

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: Garassino & De Angeli (2004b) reported one specimen (MSNM i 26283) from Favignana Island (Sicilia).

Parthenope nummulitica (Bittner, 1875)

1875 – *Lambrus nummuliticus* Bittner; p. 79, Pl. 1 (fig. 11)
1910a – *Lambrus nummuliticus* Bittner *in* Fabiani; p. 22
1915 – *Lambrus nummuliticus* Bittner *in* Fabiani; p. 284
1929 – *Parthenope*? *nummulitica* (Bittner) *in* Glaessner; p. 307
1983 – *Parthenope nummulitica* (Bittner) *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 62, Pl. 2 (fig. 2)
1994 – *Parthenope nummulitica* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 182, Pl. 6 (fig. 3)
2001 – *Parthenope nummulitica* (Bittner) *in* De Angeli & Beschin; p. 28
2004 – *Parthenope nummulitica* (Bittner) *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2006 – *Parthenope nummulitica* (Bittner) *in* Beschin, De Angeli, Checchi & Mietto; p. 107, Pl. 2 (fig. 8)

Holotype: MNHB K. 109, MB.A. 659.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Bittner (1875) reported one specimen (MNHB K109, MB.A. 661) from S. Giovanni Ilarione (Verona); Busulini *et al.* (1983) reported one specimen (*28) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported two specimens (MCZ 1307, 1433) from "Boschetto" quarry of Nogarole Vicen-tino (Vicenza); Beschin *et al.* (2006) reported one specimen (MCZ 2444) from Grotta della Poscola (Vicenza).

Parthenope sp.

1891b – *Lambrus* sp. *in* Ristori; p. 21, Pl. 1 (figs. 26-28)

Stratigraphic range: Pliocene.
Occurrence: Lazio.

Material: Ristori (1891b) reported some specimens from Monte Mario, housed in Zuccari's and Clerici's collections (repository and catalogue number unknown).

Parthenope sp.

1895 – *Lambrus* sp. *in* Crema; p. 674, Text-fig. 14

Stratigraphic range: Miocene.
Occurrence: Piemonte.
Material: Crema (1895) reported some specimens from Torino, today lost.

Parthenope sp.

1914 – *Lambrus* sp. *in* M. Gemmellaro; p. 58, Pl. 1 (figs. 16-17)

Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported some specimens from Monte Pellegrino and Ficarazzi (Palermo) (MGUP, catalogue number unknown) and Marchese di Monterosato's collection (repository and catalogue number unknown).

Parthenope sp.

2004a – *Parthenope* sp. *in* Garassino & De Angeli; p. 41, Text-figs. 3 (1-3), 4 (6)

Stratigraphic range: Pliocene, Pleistocene.
Occurrence: Emilia Romagna.
Material: Garassino & De Angeli (2004a) reported four specimens (MG 0631, 0640, 0641, 0642) from Fiume Arda (Piacenza) and Torrente Stirone (Parma).

Superfamily Retroplumoidea Gill, 1894
Family Retroplumidae Gill, 1894

Loerenthopluma Beschin, Busulini, De Angeli & Tessier, 1996

Type species: *Loerenthopluma lata* Beschin, Busulini, De Angeli & Tessier, 1996.
Stratigraphic range: middle Eocene (Lutetian).

Loerenthopluma lata Beschin, Busulini, De Angeli & Tessier, 1996

1996b – *Loerenthopluma lata* Beschin, Busulini, De Angeli & Tessier; p. 89, Text-fig. 3, Pl. 1 (fig. 1)
1998 – *Loerenthopluma lata* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 31, Text-figs. 15 (4), 17
2000 – *Loerenthopluma lata* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Loerenthopluma lata* Beschin, Busulini, De Angeli & Tessier in De Angeli & Beschin; p. 28, Text-fig. 21 (1)

Holotype: MCZ 1476 (I.G. 286351).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1996b) reported two specimens (MCZ 1476, 1477) from "Rossi" quarry of Monte di Malo (Vicenza).

Retrocypoda Via Boada, 1959

Type species: *Retrocypoda almelai* Via Boada, 1959.
Stratigraphic range: middle Eocene (Lutetian).

Retrocypoda almelai Via Boada, 1959

1959 – *Retrocypoda almelai* Via Boada; p. 394, Text-fig. 20
1969 – *Retrocypoda almelai* Via Boada *in* Via Boada; p. 331, Text-fig. 41, Pl. 38 (fig. 4); Pl. 39 (figs. 1-5)
1980 – *Retrocypoda almelai* Via Boada *in* Via Boada; p. 8, Pl. 1 (fig. 5)
1989 – *Retrocypoda almelai* Via Boada *in* Solè & Via Boada; p. 31
1996b – *Retrocypoda almelai* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 96, Text-fig. 5, Pl. 2 (fig. 1 a-c)
2001 – *Retrocypoda almelai* Via Boada *in* De Angeli & Beschin; p. 28, Text-fig. 21 (3)

Holotype: MGSB 15.942.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1996b) reported one specimen (MCZ 1475) from "Albanello" quarry of Nogarole Vicentino (Vicenza).
Note: this species is also reported from the Eocene of Spain.

Retropluma Gill, 1894

Type species: *Archaeoplax notopus* Alcock &Anderson, 1894.
Stratigraphic range: Eocene – Recent.

Retropluma craverii (Crema, 1895)

1895 – *Goneplax craverii* Crema; p. 675, Text-fig. 16
1969 – *Retropluma craverii* (Crema) *in* Via Boada; p.
1996b – *Retropluma craverii* (Crema) *in* Beschin, Busulini, De Angeli & Tessier; p. 95
2004a – *Retropluma craverii* (Crema) *in* Garassino & De Angeli; p. 45
2004 – *Retropluma craverii* (Crema) *in* Garassino, De Angeli, Gallo & Pasini; p. 255

Holotype: MCC.
Stratigraphic range: upper Pliocene (Piacentian).
Occurrence: Piemonte.
Material: Crema (1895) reported one specimen from Bra (Cuneo) (MCC, catalogue number unknown).

Retropluma eocenica Via Boada, 1959

1959 – *Retropluma eocenica* Via Boada; p. 392, Text-fig. 19
1969 – *Retropluma eocenica* Via Boada *in* Via Boada; p. 323, Text-fig. 40, Pl. 38 (figs.1-3)
1980 – *Retropluma eocenica* Via Boada *in* Via Boada; p. 56, Pl. 1 (fig. 3)
1982 – *Retropluma eocenica* Via Boada *in* Via Boada; p. 18, Text-fig. 1
1989 – *Retropluma eocenica* Via Boada *in* Solè & Via Boada; p. 31

1996b – *Retropluma eocenica* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 92, Text-fig. 4, Pl. 1 (figs. 2-4)
2001 – *Retropluma eocenica* Via Boada *in* De Angeli & Beschin; p. 29, Text-figs. 21 (2), 22
2004 – *Retropluma eocenica* Via Boada *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MGSB 20.101.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1996b) reported nine specimens (MCZ from 1467 to 1474, 1478) from "Albanello" quarry of Nogarole Vicentino (Vicenza) and "Main" quarry of Arzignano (Vicenza).
Note: this species is also reported from the Eocene of Spain.

Retropluma cfr. *R. eocenica* Via Boada, 1959

2003 – *Retropluma* cfr. *R. eocenica* Via Boada *in* Larghi; p. 59, Text-figs. 2-3 a

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte.
Material: Larghi (2003) reported one specimen (MSNM i26238) from Ponzone (Alessandria).

Superfamily Cancroidea Latreille, 1802
Family Atelecyclidae Ortmann, 1893

Atelecyclus Leach, 1814

Type species: *Cancer rotundatus* Olivi, 1792.
Stratigraphic range: ?Eocene – Recent.

Atelecyclus elegans Ristori, 1896

1896 – *Atelecyclus elegans* Ristori; p. 508, Pl. 12 (fig. 2)
1929 – *Atelecyclus elegans* Ristori *in* Glaessner; p. 62
1981 – *Atelecyclus elegans* Ristori *in* Delle Cave; p. 46

Holotype: IGF 839E.
Stratigraphic range: middle Miocene (Helvetian).
Locality: Piemonte.
Material: Ristori (1896) reported one specimen from Albugnano (Torino).

Atelecyclus rotundatus (Olivi, 1792)

1792 – *Cancer rotundatus* Olivi; p. 47, Pl. 2 (fig. 2)
1813 – *Cancer hippa septemdentatus* Montagu; p. 1, Pl. 1 (fig. 1)
1815 – *Atelecyclus heterodon* Leach; p. 2, Text-figs. 1-2
1863 – *Atelecyclus heterodon* Leach *in* Heller; p. 133
1888 – *Atelecyclus heterodon* Leach *in* Gourret; p. 55, Pl. 1 (figs. 1-17)
1905 – *Atelecyclus rotundatus* (Olivi) *in* Checchia-Rispoli; p. 86-98, Text-fig. 1
1914 – *Atelecyclus rotundatus* var. *checchiai* M. Gemmellaro; p. 89, Pl. 1 (figs. 24-25), **nov. syn.**
1918 – *Atelecyclus rotundatus* (Olivi) *in* Pesta; p. 382, Text-fig. 122
1929 – *Atelecyclus rotundatus* var. *checchiai* M. Gemmallaro *in* Glaessner; p. 62
1936 – *Atelecyclus heterodon* Leach *in* Nobre; p. 25, Pl. 8 (fig. 14)
1928 – *Atelecyclus septemdentatus* Lebour; p. 524, Text-figs. 1 (5), 4 (24, 26-27), 5 (13-14), Pl. 2 (fig. 2), Pl. 9 (figs. 1-6), Pl. 10 (figs. 1-2)
1940 – *Atelecyclus septemdentatus* Lebour *in* Bouvier; p. 219, Text-fig. 148, Pl. 8 (fig. 6)
1946 – *Atelecyclus septemdentatus* Lebour *in* Zariquiey Alvarez; p. 149, Pl. 10 (d-e)
1956 – *Atelecyclus septemdentatus* Lebour *in* Monod; p. 148
1957 – *Atelecyclus rotundatus* (Olivi) *in* Forest; p. 472
1967 – *Atelecyclus rotundatus* (Olivi) *in* Allen; p. 29, 68, 102
1968 – *Atelecyclus rotundatus* (Olivi) *in* Zariquiey Alvarez; p. 342, Text-fig. 112 b
1969 – *Atelecyclus rotundatus* (Olivi) *in* Christiansen; p. 37, Text-fig. 13 a
1976 – *Atelecyclus rotundatus* (Olivi) *in* Turkey; p. 37
1980 – *Atelecyclus rotundatus* (Olivi) *in* Ingle; p. 103, Text-fig. 46, Pl. 14 a
1992 – *Atelecyclus rotundatus* (Olivi) *in* Falciai & Minervini; p. 196
2004b – *Atelecyclus rotundatus* (Olivi) *in* Garassino & De Angeli; p. 23, Text-figs. 3, 5

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1905) reported one specimen from Monte Pellegrino (Palermo) (MGUP, catalogue number unknown); Garassino & De Angeli (2004b) reported one specimen (MSNM i26282) from Favignana Island (Sicilia).

Family Cancridae Latreille, 1802

Cancer Linnaeus, 1758

Type species: *Cancer pagurus* Latreille, 1810.
Stratigraphic range: Miocene – Recent.

Cancer spinosus (Ristori, 1886)

1886 – *Pilumnus spinosus* Ristori; p. 104, Pl. 2 (fig. 8)
1891b – *Pilumnus spinosus* Ristori *in* Ristori; p. 20
1892b – *Pilumnus spinosus* Ristori *in* Ristori; p. 90
1929 – *Cancer spinosus* (Ristori) *in* Glaessner; p. 108

Holotype: lost.
Stratigraphic range: upper Pliocene (Piacentian).
Occurrence: Lazio, Sicilia.
Material: Ristori (1886) reported one specimen from Tremonte (Sicilia) today lost; Ristori (1891b) reported one specimen from Monte Mario (Roma), housed in Zuccari's collection (MGPUR, catalogue number unknown); Ristori (1892b) reported some specimens from the Pianosa Island (repository and catalogue number unknown).

Ceronnectes De Angeli & Beschin, 1998

Type species: *Cancer böckhi* Lörenthey, 1897.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).

Ceronnectes boeckhi (Lörenthey, 1897)

1897 – *Cancer Böckhi* Lörenthey; p. 99

1898 – *Cancer Böckhi* Lörenthey *in* Lörenthey; p. 57, Pl. 4 (fig. 5)
1929 – *Necronectes Böckhi* (Lörenthey) *in* Lörenthey & Beurlen; p. 168, Pl. 8 (fig. 8)
1929 – *Necronectes Böckhi* (Lörenthey) *in* Glaessner; p. 265
1998 – *Ceronnectes boeckhi* (Lörenthey) *in* De Angeli & Beschin; p. 89, Text-figs. 1-2
2001 – *Ceronnectes boeckhi* (Lörenthey) *in* De Angeli & Beschin; p. 32
2004 – *Ceronnectes boeckhi* (Lörenthey) *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: unknown
Stratigraphic range: middle/upper Eocene.
Occurrence: Veneto.
Material: De Angeli & Beschin (1998) reported one specimen (MCZ 1563) from "Main" quarry of Arzignano (Vicenza).

Note: *Ceronnectes boeckhi* must be included in the family Cancridae Latreille, 1802, as pointed out by Lörenthey (1897). This species is also reported from the upper Eocene of Hungary. *Anisospinos* Schweitzer & Feldmann, 2000, has a carapace with five evenly-spaced frontal spine including inner-orbital spine, orbits broad, deeply excavated, with well-developed rim; anterolateral margin with eight spines including outer-orbital spine, spines separated to bases; third and fourth, fifth and sixth, and seventh and eighth anterolateral spines paired; posterolateral margin entire, rim weak if present; carapace regions distinct, granular or ornamented with tubercles. *Anisospinos* and *Ceronnectes* have shape and morphological characters of the carapace very similar. The only difference between the two genera is the more (in *Anisospinos*) or less (in *Ceronnectes*) development of the frontal and inner-orbital spine of *Anisospinos*. This difference must be considered as infraspecific and therefore *Anisospinos* could be considered as synonym with *Ceronnectes*.

Lobocarcinus Reuss, 1857

Type species: *Cancer paulinowurttembergensis* v. Meyer, 1847.
Stratigraphic range: Miocene – Recent.

Lobocarcinus sismondai (v. Meyer, 1843)

1822 – *Cancer punctulatus* Desmarest; p. 92, Pl. 7 (figs. 3-4)
1839 – *Cancer punctulatus* Desmarest *in* A. Sismonda; p. 93, Text-figs. A-B
1843 – *Cancer sismondae* v. Meyer; p. 590
1846 – *Platycarcinus antiquus* E. Sismonda; p. 58, Pl. 3 (figs. 1-2), **nov. syn.**
1857 – *Platycarcinus antiquus* E. Sismonda *in* Meneghini; p. 528, Pl. H (fig. 11)
1858 – *Lobocarcinus sismondai* (v. Meyer) *in* Reuss; p. 41, Pl. 9 (figs. 1-2)
1858 – *Lobocarcinus imperator* Reuss; p. 41, Pls. 7-8, Pl. 9 (fig. 1)
1861 – *Platycarcinus sismondae* (v. Meyer) *in* E. Sismonda; p. 18
1861 – *Platycarcinus deshayesii* A. Milne Edwards; p. 88
1861 – *Cancer sismondai* v. Meyer *in* Michelotti; p. 140
1864 – *Cancer sismondae* (v. Meyer) *in* A. Milne Edwards; p. 316, Pls. 24-25
1864 – *Cancer deshayesii* (A. Milne Edwards) *in* A. Milne Edwards; p. 314, Pl. 22 (figs. 1-2), Pl. 23 (fig. 1)
1875 – *Platycarcinus sismondai* (v. Meyer) *in* Bittner; p. 23
1886 – *Cancer sismondae* (v. Meyer) *in* Ristori; p. 95, Pl. 2 (fig. 1)
1887 – *Cancer sismondae* (v. Meyer) *in* Mariani & Parona; p. 152
1889 – *Cancer sismondae* (v. Meyer) *in* Ristori; p. 217
1891a – *Cancer sismondae* (v. Meyer) *in* Ristori; p. 4
1893 – *Cancer* cfr. *illyricus in* Bittner; p. 32
1895 – *Cancer sismondae* (v. Meyer) *in* Crema; p. 679, Text-fig. 19 a-c
1896 – *Platycarcinus sismondai* (v. Meyer) *in* Vinassa de Regny; p. 124, Pl. 2 (fig. 1 a-b)
1903 – *Cancer sismondae* (v. Meyer) *in* Lörenthey; p. 32
1907 – *Cancer sismondae* (v. Meyer) *in* Lörenthey; p. 204, 208, 210
1908? – *Cancer sismondae* (v. Meyer) *in* Couffon; p. 5, Pl. 2 (figs. 3-4)
1908? – *Cancer deshayesii* (A. Milne Edwards) *in* Couffon; p. 5, Pl. 2 (fig. 11)
1909 – *Cancer sismondae* (A. Milne Edwards) *in* Lörenthey; p. 240
1910a – *Cancer sismondae* (v. Meyer) *in* Fabiani; p. 33
1921 – *Cancer deshayesii* (A. Milne Edwards) *in* Bell; p. 7
1924 – *Cancer* (*Lobocarcinus*) *sismondae* (v. Meyer) *in* Glaessner; p. 115
1927 – *Cancer deshayesii* (A. Milne Edwards) *in* Van Straelen; p. 87, Pl. 3 (fig. 2), Pl. 4 (figs. 1-2)
1929 – *Cancer sismondai* (v. Meyer) *in* Glaessner; p. 106
1929 – *Cancer sismondai* (v. Meyer) *in* Lörenthey; p. 161
1934 – *Cancer deshayesii* (A. Milne Edwards) *in* Van Straelen; p. 207
1934 – *Cancer sismondai* (v. Meyer) *in* Van Straelen; p. 207
1946 – *Cancer sismondai* var. *antiatina*, Maxia; p. 134, Text-fig. 1, Pl. 1 (figs. 2-5), **nov. syn.**
1950 – *Cancer sismondae* (v. Meyer) *in* Comaschi Caria; p. 326
1950 – *Platycarcinus antiquus* E. Sismonda *in* Comaschi Caria; p. 327
1956 – *Cancer sismondai* (v. Meyer) *in* Comaschi Caria; p. 282, 284, 288
1956 – *Platycarcinus antiquus* E. Sismonda *in* Comaschi Caria; p. 283
1961 – *Cancer sismondai* var. *antiatina* Maxia *in* Zappi; p. 86
1965 – *Cancer sismondai* (v. Meyer) *in* Varola; p. 295
1965 – *Cancer sismondai* var. *antiatina* Maxia *in* Giannelli, Salvatorini & Tavani; p. 521
1969 – *Cancer sismondai* var. *antiatina* Maxia *in* Largaiolli, Martinis, Nardin, Rossi & Ungaro; p. 29
1969 – *Cancer sismondai* var. *antiatina* Maxia *in* Rossi; p. 22
1977 – *Cancer* cfr. *sismondai* (v. Meyer) *in* Georgiades Dikeoulia; p. 420
1981 – *Cancer sismondai* (v. Meyer) *in* Varola; p. 16, Pl. 3 (figs. 5-6), Pl. 4 (figs. 1-2), Pl. 5 (figs. 1-2), Pl. 6 (figs. 2, 4)
1982 – *Cancer sismondai* (v. Meyer) *in* Via Boada, Martinell & Domènech; p. 242, Pls. 1-2
1982 – *Cancer sismondai* (v. Meyer) *in* Bonfiglio & Donadeo; p. 270, Text-figs. 5-27, Pls. 33-44
1982 – *Cancer sismondai* (v. Meyer) *in* Bonfiglio; p. 5, Text-figs. 1-4, Pls. 1-7
1984 – *Cancer sismondai* (v. Meyer) *in* Müller; p. 75
1988 – *Cancer sismondai* (v. Meyer) *in* Solé & Via Boada; p. 35
1990 – *Cancer sismondai* (v. Meyer) *in* Moisette & Müller; p. 739, Pl. 1 (fig. 1), Pl. 2 (figs. 1-2)
1993 – *Cancer sismondai* (v. Meyer) *in* Müller; p. 14
1997 – *Cancer sismondai* (v. Meyer) *in* Beschin & Santi; p. 13, Pl. 1 (figs. 1-2)
1998 – *Cancer sismondai* (v. Meyer) *in* Müller; p. 28
2000 – *Cancer sismondai* (v. Meyer) *in* Garassino & Fornaciari; p. 29, Text-fig. 1
2000 – *Lobocarcinus sismondai* (v. Meyer) *in* Schweitzer & Feldmann; p. 244

2002 – *Lobocarcinus sismondai* (v. Meyer) *in* Collins; p. 86
2002 – *Lobocarcinus sismondae* (v. Meyer) *in* Bortoluzzi; p. 17, Text-fig. 7
2004a – *Lobocarcinus sismondae* (v. Meyer) *in* Garassino & De Angeli; p. 42, Text-figs. 9-11

Holotype: unknown.
Stratigraphic range: Miocene – Pleistocene.
Occurrence: Piemonte, Emilia Romagna, Lazio, Puglia, Calabria, Sardegna, Sicilia.
Material: Meneghini (1857) reported some specimens from Capo S. Marco (Oristano) (repository and catalogue number unknown); A. Sismonda (1839) reported two specimens from S. Stefano Roero (Asti), today lost; E. Sismonda (1846) reported one specimen from Quaglina (Asti), housed in the Sotteri's collection, today lost; A. Milne Edwards (1861) reported one specimen (MNHN A24543) from Alba; Ristori (1886) reported some specimens from Quaglina, S. Stefano Roero and Verruca Savoja (Asti), Monte Capriolo (Bra) (repository and catalogue number unknown), four specimens from Fornaci (Savona), today lost, and some specimens from Tremonte (Sicilia) (repository and catalogue number unknown); Ristori (1891a) reported one specimen from Anzio Tor Caldara (Roma), housed in Clerici's collection (MGPUR, catalogue number unknown); Crema (1895) reported some specimens from Bra (repository and catalogue number unknown); Vinassa de Regny (1896) reported one specimen from Lesignano dei Bagni (Parma) (MGPUP, catalogue number unknown); Lörenthey (1909) reported some specimens from Cagliari (Sardegna), housed in Lovisato's collection (repository and catalogue number unknown); Maxia (1946) reported one specimen from Anzio (Roma), housed in Clerici's collection today lost; Comaschi Caria (1950) reported this species from Capo S. Marco (Oristano) (repository and catalogue number unknown); Varola (1965) reported 13 specimens from Porto Graulo (Lecce) (repository and catalogue number unknown); Varola (1981) reported 102 specimens from Porto Craulo (Otranto) (MPUP and GNSL, catalogue number unknown); Bonfiglio & Donadeo (1982) reported 28 specimens from Torre dell'Orso (Lecce) (MPM, catalogue number unknown); Beschin & Santi (1997) reported four specimens (MCV A, B; MCZ 1572, 1573) from Vignola (Modena); Garassino & Fornaciari (2000) reported ten specimens from Fiume Enza (Parma), housed in a private collection (catalogue number unknown); Bortoluzzi (2002) reported one specimen (MGPD 28976) from Strongoli (Catanzaro); Garassino & De Angeli (2004a) reported eight specimens (MG 0564, 0565, 0613, 0619, from 0615 to 0618) from Fiume Arda (Piacenza), Fiume Enza, and Campore quarry (Parma).
Note: this species is also reported from the Miocene-Pleistocene of Great Britain, the Netherlands, Spain, Hungary, Greece, Austria, and Algeria.

Family Cheiragonidae Ortmann, 1893

Montezumella Rathbun, 1930

Type species: *Montezumella tubulata* Rathbun, 1930.
Stratigraphic range: Eocene – Miocene.

Montezumella elegans (Lörenthey & Beurlen, 1929)

1929 – *Titanocarcinus elegans* Lörenthey & Beurlen; p. 235, Pl. 11 (fig. 3)
1981 – *Montezumella elegans* (Lörenthey & Beurlen) *in* Quayle & Collins; p. 748
1995 – *Montezumella elegans* (Lörenthey & Beurlen) *in* De Angeli; p. 14, Text-fig. 3 (1), Pl. 1 (fig. 7), Pl. 2 (fig. 1)
2001 – *Montezumella elegans* (Lörenthey & Beurlen) *in* De Angeli & Beschin; p. 29, Text-fig. 23

Holotype: unknown.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli (1995) reported two specimens (MCZ 1496, 1497), from "Fontanella" di Grancona (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Montezumella pumicosa Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Montezumella pumicosa* Beschin, Busulini, De Angeli & Tessier; p. 16, Text-fig. 11, Pl. 3 (fig. 1 a-b)
2004 – *Montezumella pumicosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MCZ 2274 (I.G. 296402).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported one specimen (MCZ 2274) from "Main" quarry of Arzignano (Vicenza).

Montezumella scabra Quayle & Collins, 1981

1981 – *Montezumella scabra* Quayle & Collins; p. 747, Pl. 105 (fig. 1)
1983 – *Montezumella* cfr. *scabra* Quayle & Collins *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 63, Pl. 3 (fig. 6)
1994 – *Montezumella scabra* Quayle & Collins *in* Beschin, Busulini, De Angeli & Tessier; p. 183, Pl. 6 (fig. 4)
2001 – *Montezumella scabra* Quayle & Collins *in* De Angeli & Beschin; p. 29

Holotype: NHM 61711.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Busulini *et al.* (1983) reported four specimens (*143, *8, *144; MSNV 10093), from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported one specimen (MCZ 1287), from "Boschetto" quarry of Nogarole Vicentino (Vicenza).
Note: this species is also reported in the upper Eocene of Great Britain.

Superfamily Portunoidea Rafinesque-Schmaltz, 1815
Family Geryonidae Colosi, 1924

Coeloma A. Milne Edwards, 1865

Type species: *Coeloma vigil* A. Milne Edwards, 1865.

Stratigraphic range: Eocene – Oligocene.

Coeloma isseli Ristori, 1886

1886 – *Coeloma isseli* Ristori; p. 119, Pl. 2 (fig. 10)
1923 – *Coeloma* isseli Ristori *in* Tettoni; p. 161
1929 – *Coeloma* sp. *in* Glaessner; p. 122
1929 – *Coeloma*? *isseli* Ristori *in* Glaessner; p. 120
1981 – *Coeloma isseli* Ristori *in* Delle Cave; p. 48

Syntype: IGF 959E (figured by Ristori in Pl. 2, fig. 10).
Stratigraphic range: Pliocene.
Occurrence: Emilia Romagna.
Material: Ristori (1886) reported some specimens (IGF from 960E to 971E, syntypes) from S. Venanzio (Modena); Tettoni (1923) reported one specimen from S. Venanzio (Modena) (MGUM, catalogue number unknown).

Coeloma sabatium Ristori, 1886

1886 – *Coeloma sabatium* Ristori; p. 117, Pl. 2 (figs. 11-12, 17)
1887 – *Coeloma rupeliense* Stainier; p. 87
1929 – *Coeloma sabatium* Ristori *in* Glaessner; p. 121

Holotype: lost.
Stratigraphic range: Pliocene.
Occurrence: Liguria.
Material: Ristori (1886) reported one specimen from Fornaci (Savona), housed in don Perrando's collection, today lost.

Coeloma vigil A. Milne Edwards, 1865

1861 – *Cancer beggiatoi* Michelotti; p. 140, Pl. 14 (figs. 1-2)
1865 – *Coeloma vigil* A. Milne Edwards; p. 352, Pl. 35 (figs. 1-3)
1875 – *Coeloma vigil* A. Milne Edwards *in* Bittner; p. 97, Pl. 5 (figs. 1-4)
1883 – *Coeloma vigil* A. Milne Edwards *in* Bittner; p. 314
1889 – *Coeloma vigil* A. Milne Edwards *in* Ristori; p. 403, Pl. 15 (figs. 4-5)
1901 – *Coeloma vigil* A. Milne Edwards *in* Oppenheim; p. 283
1910a – *Coeloma vigil* A. Milne Edwards *in* Fabiani; p. 33
1915 – *Coeloma vigil* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Coeloma vigil* A. Milne Edwards *in* Glaessner; p. 122
1929 – *Coeloma vigil* A. Milne Edwards *in* Lörenthey & Beurlen; p. 243, Pl. 15 (fig. 16)
1969 – *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards *in* Glaessner; 524, Text-fig. 332 (2 a)
1974 – *Coeloma vigil* A. Milne Edwards *in* Mastrorilli; p. 4, Text-fig. without number
1987 – *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards *in* Allasinaz; p. 542, Text-fig. 12, Pl. 6 (figs. 1-4), Pl. 7 (figs. 1-5)
2001 – *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards *in* De Angeli & Beschin; p. 29, Text-fig. 24
2004 – *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards *in* Garassino, De Angeli, Gallo & Pasini; p. 270

Holotype: MNHN R03822.
Stratigraphic range: upper Eocene (Priabonian) – lower Oligocene (Rupelian).
Occurrence: Piemonte, Liguria, Veneto.
Material: A. Milne Edwards (1862-1865) reported two specimens (MNHN R03822, R03794) from the "nummulitico" of Vicenza; Bittner (1875) reported this species from Laverda (Vicenza) (repository and catalogue number unknown); Ristori (1889) reported two specimens from Sassello (Savona), housed in don Perrado's collection today in "DIP.TE.RIS" (we identified one original specimen: 2389/Sa-II-S186 (ex Sa-II-S205), figured in Pl. 15, figs. 4-5); Allasinaz (1987) reported 30 specimens from Ciglione, Ponzone, Fontanino di Rio Caramagna, Rio Volpina and Case Cherpione (MCSN, catalogue number unknown); Garassino *et al.* (2004) reported three specimens (MSNM from i26279 to i26281) from Case Cherpione (Ovada).

Note: this species is also reported from the Oligocene of Hungary.

Family Portunidae Rafinesque-Schmaltz, 1815

Boschettia Busulini, Tessier, Beschin & De Angeli, 2003

Type species: *Boschettia giampietroi* Busulini, Tessier, Beschin & De Angeli, 2003.
Stratigraphic range: middle Eocene (Lutetian).

Boschettia giampietroi Busulini, Tessier, Beschin & De Angeli, 2003

1994 – *Coeloma* (*Paracoeloma*) sp. *in* Beschin, Busulini, De Angeli & Tessier; p. 190, Text-fig. 7, Pl. 9 (fig. 6)
2003 – *Boschettia giampietroi* Busulini, Tessier, Beschin & De Angeli; p. 15, Text-figs. 2-4

Holotype: MCZ 2401 (I.G. 296785).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported one specimen (MCZ 1447) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Busulini *et al.* (2003) reported two specimens (MCZ 1447, 2401) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Carcinus Leach, 1814

Type species: *Cancer maenas* Linnaeus, 1758.
Stratigraphic range: Eocene – Recent.

Carcinus sp.

2004a – *Carcinus* sp. *in* Garassino & De Angeli; p. 44, Text-fig. 8

Stratigraphic range: Pliocene.
Occurrence: Emilia Romagna.
Material: Garassino & De Angeli (2004a) reported four specimens (MG from 0643 to 0646) from Campore quarry (Parma).

Carcinus sp.

2004 – *Carcinus* sp. *in* Garassino, De Angeli, Gallo & Pasini; p. 269

Stratigraphic range: Pliocene.
Occurrence: Piemonte.
Material: Garassino *et al.* (2004) reported four specimens (PU from 41176 to 41179) from Cossato (Biella).

Charybdis De Haan, 1833

Type species: *Cancer feriatus* Linnaeus. 1758.
Stratigraphic range: Oligocene – Recent.

Charybdis antiqua (A. Milne Edwards, 1860)

1860 – *Goniosoma antiqua* A. Milne Edwards; p. 265, Pl. 5 (fig. 4)
1875 – *Goniosoma antiqua* A. Milne Edwards *in* Bittner; p. 83
1910a – *Charybdis antiqua* (A. Milne Edwards) *in* Fabiani; p. 24
1915 – *Charybdis antiqua* (A. Milne Edwards) *in* Fabiani; p. 285
1929 – *Charybdis antiqua* (A. Milne Edwards) *in* Glaessner; p. 113
2001 – *Charybdis antiqua* (A. Milne Edwards) *in* De Angeli & Beschin; p. 31

Holotype: unknown.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: A. Milne Edwards (1862-1865) reported this species from Salcedo (Vicenza) (repository and catalogue number unknown).

Enoplonotus A. Milne Edwards, 1860

Type species: *Enoplonotus armatus* A. Milne Edwards, 1860.
Stratigraphic range: Eocene.

Enoplonotus armatus A. Milne Edwards, 1860

1860 – *Enoplonotus armatus* A. Milne Edwards; p. 247, Pl. 7 (figs. 1, 1 a)
1915 – *Enoplonotus armatus* A. Milne Edwards *in* Fabiani; p. 284
1929 – *Enoplonotus armatus* A. Milne Edwards *in* Glaessner; p. 149
1975 – *Enoplonotus armatus* A. Milne Edwards *in* Secretan; p. 359, Pl. 21 (figs. 1-2)

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: A. Milne Edwards (1862-1865) reported one specimen (? Massalongo's collection) from Monte Bolca (Verona) (repository and catalogue number unknonw); Secretan (1975) reported two specimens (MSNV M1, M2) from Monte Bolca (Verona).

Eocharybdis Beschin, Busulini, De Angeli & Tessier, 2002

Type species: *Eocharybdis cristata* Beschin, Busulini, De Angeli & Tessier, 2002.
Stratigraphic range: middle Eocene (Lutetian).

Eocharybdis cristata Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Eocharybdis cristata* Beschin, Busulini, De Angeli & Tessier; p. 17, Text-fig. 12, Pl. 3 (fig. 2)
2004 – *Eocharybdis cristata* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MCZ 2275 (I.G. 296403).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported one specimen (MCZ 2275) from "Main" quarry of Arzignano (Vicenza).

Liocarcinus Stimpson, 1871

Type species: *Portunus holsatus* Fabricius, 1798.
Stratigraphic range: Oligocene – Recent.

Liocarcinus cfr. *L. rakosensis* (Lörenthey & Beurlen, 1929)

2004 – *Liocarcinus* cfr. *L. rakosensis* (Lörenthey & Beurlen) *in* Garassino, De Angeli, Gallo & Pasini; p. 269, Text-fig. 11

Stratigraphic range: upper Miocene (Messinian).
Occurrence: Piemonte.
Material: Garassino *et al.* (2004) reported one specimen (PU 41198) from Cocconato (Asti).
Note: this species is also reported from the Miocene of Hungary.

Macropipus Prestandrea, 1833

Type species: *Portunus macropipus* Prestandrea, 1833.
Stratigraphic range: Eocene – Recent.

Macropipus ovalipes Secretan, 1975

1975 – *Macropipus ovalipes* Secretan; p. 348, Text-figs. 12-18, Pls. 17-20

Holotype: MSNV es. 8.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported one specimen (MSNV es. 8) from Monte Bolca (Verona).

Necronectes A. Milne Edwards, 1881

Type species: *Necronectes vidalianus* A. Milne Edwards, 1881.
Stratigraphic range: Oligocene – Miocene.

Necronectes schafferi Glaessner, 1928

1928 – *Necronectes schafferi* Glaessner; p. 179, Text-fig. 3, Pl. 3 (fig. 6)
1929 – *Scylla* cf. *michelini* A. Milne Edwards *in* Glaessner; p. 184
1929 – *Scylla* sp. cf. *michelini* A. Milne Edwards *in* Lörenthey & Beurlen; p. 178, Pl. 15 (figs. 5-6)
1929 – *Necronectes schafferi* Glaessner *in* Glaessner; p. 265
1933 – *Necronectes schafferi* Glaessner *in* Glaessner; p. 3, Pl. 1 (fig. 1)
1992 – *Necronectes schafferi* Glaessner *in* De Angeli & Marangon; p. 177, Pl. 1 (figs. 1-2), Pl. 2 (fig. 1 a-b)
1993 – *Necronectes batalleri* Via Boada *in* Müller; p. 30, Pl. 2 (fig. 3)
1998 – *Necronectes schafferi* Glaessner *in* Müller; p. 30

Holotype: MHMW 1927/I/1.
Stratigraphic range: lower/middle Miocene (Burdigalian – Langhian).
Occurrence: Sardegna.

Material: De Angeli & Marangon (1992) reported one specimen (MCZ 1362) from Tresnuraghes (Oristano).

Note: this species is also reported from the Miocene of Austria, Hungary, Poland, Spain, and Malta.

Neptocarcinus Lörenthey, 1897

Type species: *Neptocarcinus millenaris* Lörenthey, 1897.

Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).

Neptocarcinus millenaris Lörenthey, 1897

1897 – *Neptocarcinus millenaris* Lörenthey; p. 156

1898 – *Neptocarcinus millenaris* Lörenthey *in* Lörenthey; p. 179, Pl. 4 (fig. 3)

1929 – *Neptocarcinus millenaris* Lörenthey *in* Lörenthey & Beurlen; p. 216, Pl. 10 (fig. 3)

1983 – *Neptocarcinus millenaris* Lörenthey *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 66, Pl. 3 (fig. 3)

1991 – *Neptocarcinus millenaris* Lörenthey *in* Müller & Collins; p. 70, Text-fig. 4 a, Pl. 4 (fig. 11)

2001 – *Neptocarcinus millenaris* Lörenthey *in* De Angeli & Beschin; p. 32

2004 – *Neptocarcinus millenaris* Lörenthey *in* Beschin, Busulini, De Angeli & Tessier; p. 115

2005 – *Neptocarcinus millenaris* Lörenthey *in* Beschin, De Angeli, Checchi & Zarantonello; p. 22, Text-fig. 14, Pl. 4 (fig. 7)

Holotype: MAFI.

Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).

Occurrence: Veneto.

Material: Busulini *et al.* (1983) reported five specimens (*1, *2, *3, *23; MSNVE 10096) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported ten specimens (MCZ 2300, 2301, 2351, 2352, 2374, 2375, 2376, 2380; MV 54, 04/15) from Grola di Cornedo Vicentino (Vicenza).

Note: this species is also reported from the upper Eocene of Hungary.

Nogarolia Beschin, Busulini, De Angeli & Tessier, 1994

Type species: *Nogarolia mirabilis* Beschin, Busulini, De Angeli & Tessier, 1994.

Stratigraphic range: middle Eocene (Lutetian).

Nogarolia mirabilis Beschin, Busulini, De Angeli & Tessier, 1994

1994 – *Nogarolia mirabilis* Beschin, Busulini, De Angeli & Tessier; p. 184, Text-fig. 6, Pl. 7 (fig. 1 a-b)

2001 – *Nogarolia mirabilis* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 32, Text-fig. 26

Holotype: MCZ 1420 (I.G. 284609).

Stratigraphic range: middle Eocene (Lutetian).

Occurrence: Veneto.

Material: Beschin *et al.* (1994) reported one specimen (MCZ 1420) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Portunites Bell, 1858

Type species: *Portunites incertus* Bell, 1858.

Stratigraphic range: Eocene – Miocene.

Portunites rosenfeldi De Angeli & Garassino, 2006

2006a – *Portunites rosenfeldi* De Angeli & Garassino; p. 285, Text-figs. 9 (a-b), 10

Holotype: MFSN 28995.

Stratigraphic range: lower Eocene (Ypresian).

Occurrence: Friuli-Venezia Giulia.

Material: De Angeli & Garassino (2006a) reported two specimens (MFSN 28995, 29046) from Almadis (Pordenone).

Portunus Weber, 1795

Type species: *Cancer pelagicus* Linnaeus, 1758.

Stratigraphic range: Eocene – Recent.

Portunus arcuatus (A. Milne Edwards, 1860)

1860 – *Neptunus arcuatus* A. Milne Edwards; p. 240, Pl. 6 (figs. 2, 2 a-b)

1875 – *Neptunus arcuatus* A. Milne Edwards *in* Bittner; p. 80

1910a – *Neptunus arcuatus* A. Milne Edwards *in* Fabiani; p. 23

1915 – *Neptunus arcuatus* A. Milne Edwards *in* Fabiani; p. 285

1929 – *Neptunus arcuatus* A. Milne Edwards *in* Glaessner; p. 267

1996 – *Portunus arcuatus* (A. Milne Edwards) *in* Beschin, Checchi & Ungaro; p. 16

2001 – *Portunus* (*Portunus*) *arcuatus* (A. Milne Edwards) *in* De Angeli & Beschin; p. 30

Holotype: unknown

Stratigraphic range: Oligocene.

Occurrence: Veneto.

Material: A. Milne Edwards (1860) reported this species from Salcedo (Vicenza) (repository and catalogue number unknown).

Portunus convexus (Ristori, 1889)

1889 – *Neptunus convexus* Ristori; p. 400, Pl. 15 (fig. 1)

1929 – *Neptunus convexus* Ristori *in* Glaessner; p. 267

1950 – *Neptunus convexus* Ristori *in* Comaschi Caria; p. 326

1956 – *Neptunus convexus* Ristori *in* Comaschi Caria; p. 288

1965 – *Neptunus convexus* Ristori *in* Varola; p. 296

1969 – *Neptunus convexus* Ristori *in* Via Boada; p. 215

1974 – *Neptunus convexus* Ristori *in* Mastrorilli; p. 4

1987 – *Portunus convexus* (Ristori) *in* Allasinaz; p. 535, Text-fig. 10, Pl. 4 (figs. 3-8)

2003a – *Portunus convexus* (Ristori) *in* De Angeli & Marangon; p. 101, Text-fig. 1 (3)

Holotype: lost.

Stratigraphic range: lower Oligocene (Rupelian).

Occurrence: Liguria, Piemonte, Sardegna.

Material: Ristori (1889) reported one specimen from Sassello (Savona), housed in don Perrando's collection, today lost; Allasinaz (1987) reported 15 specimens from Ciglione, Rio Caramagna, Rio Volpina, Case Cherpione and Ponzone (Acqui) (PU; MCSN, catalogue number unknown).

Portunus cfr. *P. convexus* (Ristori, 1889)

1892c – *Neptunus* cfr. *convexus* (Ristori) *in* Ristori; p. 162
1929 – *Neptunus* cfr. *convexus* (Ristori) *in* Glaessner; p. 267

Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: Ristori (1892c) reported one specimen from Chiavon (repository and catalogue number unknown).

Portunus edwardsi E. Sismonda, 1846

1846 – *Portunus edwardsi* E. Sismonda; p. 70, Pl. 3 (fig. 9)
1861 – *Portunus edwardsi* E. Sismonda *in* E. Sismonda; p. 20
1886 – *Portunus edwardsi* E. Sismonda *in* Ristori; p. 110
1891a – *Portunus edwardsi* E. Sismonda *in* Ristori; p. 9, Pl. 1 (fig. 13)
1929 – *Portunus edwardsi* E. Sismonda *in* Glaessner; p. 334

Holotype: lost.
Stratigraphic range: Pliocene.
Occurrence: Piemonte, Toscana.
Material: E. Sismonda (1846) reported one specimen from Asti, today lost; E. Sismonda (1861) reported some specimens from Asti, today lost; Ristori (1886) reported some specimens from Asti, today lost; Ristori (1891a) reported one specimen from Spicchio (Empoli), today lost.

Portunus hastatus (Linnaeus, 1767)

1767 – *Cancer hastatus* Linnaeus; p. 1046
1863 – *Lupa hastata* (Linnaeus) *in* Heller; p. 77, Pl. 2 (fig. 10)
1918 – *Neptunus hastatus* (Linnaeus) *in* Pesta; p. 411, Text-fig. 135
1825 – *Portunus hastatus* (Linnaeus) *in* Latreille; p. 189
1933 – *Neptunus hastatus* (Linnaeus) *in* de Miranda; p. 49
1936 – *Lupa hastata* (Linnaeus) *in* Nobre; p. 41, Pl. 15, Text-figs. 37-38
1940 – *Neptunus hastatus* (Linnaeus) *in* Bouvier; p. 249, Text-fig. 160, Pl. 9 (fig. 14)
1946 – *Neptunus hastatus* (Linnaeus) *in* Zariquiey Alvarez; p. 158, Pl. 15 (b-c)
1950 – *Lupa hastata* (Linnaeus) *in* Comaschi Caria; p. 324, Pl. 1
1952 – *Neptunus hastatus* (Linnaeus) *in* Zariquiey Alvarez; p. 36
1956 – *Neptunus hastatus* (Linnaeus) *in* Monod; p. 203, Text-figs. 232-235
1956 – *Lupa hastata* (Linnaeus) *in* Comaschi Caria; p. 288
1958 – *Portunus hastatus* (Linnaeus) *in* Holthuis & Gottlieb; p. 91
1968 – *Portunus hastatus* (Linnaeus) *in* Zariquiey Alvarez; p. 384, Text-figs. 125 d-e, 126 c, 128 a-b1
1992 – *Portunus hastatus* (Linnaeus) *in* Falciai & Minervini; p. 201-202

Holotype: unknown.
Stratigraphic range: middle Miocene (Helvetian).
Occurrence: Sardegna.
Material: Comaschi Caria (1950) reported one specimen from Bosa (Nuoro) (repository and catalogue number unknown).

Portunus incertus (A. Milne Edwards, 1860)

1860 – *Neptunus incertus* A. Milne Edwards; p. 244, Pl. 5 (fig. 3)
1910a – *Neptunus incertus* A. Milne Edwards *in* Fabiani; p. 23
1915 – *Neptunus incertus* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Neptunus incertus* A. Milne Edwards *in* Glaessner; p. 268
1996 – *Portunus incertus* (A. Milne Edwards) *in* Beschin, Checchi & Ungaro; p. 16
2001– *Portunus* (*Portunus*) *incertus* (A. Milne Edwards) *in* De Angeli & Beschin; p. 30

Holotype: unknown.
Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: A. Milne Edwards (1860) reported this species from Salcedo (Vicenza) (repository and catalogue number unknown).

Portunus kochi (Bittner, 1893)

1893 – *Neptunus Kochii* Bittner; p. 22, Pl. 1 (figs. 1, 1 a)
1929 – *Neptunus Kochi* Bittner *in* Glaessner; p. 268
1929 – *Neptunus kochi* Bittner *in* Lörenthey & Beurlen; p. 185, Pl. 13 (figs. 5 a-c, 8 a-b)
1969 – *Neptunus kochi* Bittner *in* Via Boada; p. 216
1996 – *Portunus kochi* (Bittner) *in* Beschin, Checchi & Ungaro; p. 14, Text-fig. 3, Pl. 1 (figs. 1-3)
2001 – *Portunus* (*Portunus*) *kochi* (Bittner) *in* De Angeli & Beschin; p. 30, Text-fig. 25

Holotype: unknown.
Stratigraphic range: Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (1996) reported three specimens (MCZ from 1564 to 1566) from Castelgomberto (Vicenza).
Note: this species is also reported from the middle Eocene of Hungary.

Portunus larteti (A. Milne Edwards, 1860)

1860 – *Neptunus Larteti* A. Milne Edwards; p. 237, Pl. 5 (figs. 2, 2 b)
1875 – *Neptunus Lartetii* A. Milne Edwards *in* Bittner; p. 80
1910a – *Neptunus Larteti* A. Milne Edwards *in* Fabiani; p. 22
1915 – *Neptunus Larteti* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Neptunus larteti* A. Milne Edwards *in* Glaessner; p. 268
1996 – *Portunus larteti* (A. Milne Edwards) *in* Beschin, Checchi & Ungaro; p. 16
2001 – *Portunus* (*Portunus*) *larteti* (A. Milne Edwards) *in* De Angeli & Beschin; p. 30

Holotype: unknown
Stratigraphic range: Tertiary.
Occurrence: Veneto.
Material: A. Milne Edwards (1860) reported this species from the "nummulitico" of Vicenza (repository and catalogue number unknown).

Portunus monspeliensis (A. Milne Edwards, 1860)

1860 – *Neptunus monspeliensis* A. Milne Edwards; p. 106, Pl. 4 (fig. 1), Pl. 5 (fig. 1)
1860 – *Neptunus granulatus* A. Milne Edwards; p. 115, Pl. 3 (fig. 1), Pl. 7 (fig. 2), **nov. syn.**
1888 – *Neptunus granulatus* A. Milne Edwards *in* Ristori; p. 215, Pl. 4 (figs. 5-11)
1893 – *Neptunus granulatus* A. Milne Edwards *in* Bittner; p. 11
1897 – *Neptunus monspeliensis* A. Milne Edwards *in* Roman; p. 128

1898 – *Neptunus granulatus* A. Milne Edwards *in* Lörenthey; p. 92, Pl. 9 (figs. 2-3)
1901 – *Neptunus granulatus* A. Milne Edwards *in* Blanckenhorn; p. 76, 112
1909 – *Neptunus granulatus* A. Milne Edwards *in* Lörenthey; p. 242, Pl. 2 (figs. 1-2)
1911 – *Neptunus granulatus* A. Milne Edwards *in* Toula; p. 48, Text-figs. 1-2
1927 – *Neptunus granulatus* A. Milne Edwards *in* Van Straelen; p. 86
1928 – *Neptunus granulatus* A. Milne Edwards *in* Glaessner; p. 183
1929 – *Neptunus granulatus* A. Milne Edwards *in* Glaessner; p. 267
1929 – *Neptunus granulatus* A. Milne Edwards *in* Lörenthey & Beurlen; p. 188, Pl. 13 (figs. 3-4), Pl. 14 (figs. 1-4)
1950 – *Neptunus granulatus* A. Milne Edwards *in* Comaschi Caria; p. 326
1956 – *Neptunus granulatus* A. Milne Edwards *in* Comaschi Caria; p. 288, Pl. 1 (figs. 1-7), Pl. 2 (figs. 1-6), Pl. 3 (figs. 1-2)
1962 – *Neptunus granulatus* A. Milne Edwards *in* Zbyszewski & Da Veiga Ferreira; p. 286
1964-65 – *Neptunus granulatus* A. Milne Edwards *in* Da Veiga Ferreira; p. 150
1965 – *Neptunus granulatus* A. Milne Edwards *in* Varola; p. 296
1968 – *Neptunus* cfr. *N. granulatus* A. Milne Edwards *in* Stancu & Andreescu; p. 466, Pl. 7 (fig. 85)
1979 – *Portunus monspeliensis* (A. Milne Edwards) *in* Müller; p. 274, 280, 288, Pl. 18
1979 – *Portunus granulatus* A. Milne Edwards *in* Förster; p. 94
1984 – *Portunus monspeliensis* (A. Milne Edwards) *in* Müller; p. 79, Pl. 62 (figs. 1-2)
1987 – *Portunus monspeliensis* (A. Milne Edwards) *in* Allasinaz; p. 539, Pl. 4 (figs. 1-2)
1991 – *Portunus monspeliensis* (A. Milne Edwards) *in* Marras & Ventura; p. 108, Pl. 1, Pl. 2 (figs. 1-4), Pl. 3 (figs. 1-3)
1998 – *Portunus monspeliensis* (A. Milne Edwards) *in* Müller; p. 29
2006a – *Portunus monspeliensis* (A. Milne Edwards) *in* De Angeli & Garassino; p. 283, Text-fig. 8

Holotype: MNHN R03774.
Stratigraphic range: lower Miocene (Burdigalian) – middle Miocene (Langhian).
Occurrence: Piemonte, Friuli-Venezia Giulia, Emilia Romagna, Puglia, Sardegna.
Material: Ristori (1888) reported many specimens from Monte S. Michele, Flussio and Tresnuraghes (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown), some specimens from Lecce and one specimen from S. Maria Vigliana (Bologna), today lost; Lörenthey (1909) reported some specimens from Cadreas, Portotorres, Sedin, Ardara (Sassari) and Planargia (Cagliari) (repository and catalogue number unknown); Comaschi Caria (1956) reported one specimen from Bonorva and Bosa (Nuoro) (repository and catalogue number unknown); Allasinaz (1987) reported three specimens (MCSN 4M, 91M, 222) from Fontanino di Rio Caramagna, Ciglione, and Ponzone (Acqui); Marras & Ventura (1991) reported some specimens from Sassari (repository and catalogue number unknown); De Angeli & Garassino (2006a) reported two specimens (MSNM i26584, i26585) from Meduno (Pordenone).
Note: this species is also reported from the Miocene of Hungary, Spain, Austria, France, and Egypt.

Portunus neogenicus Müller, 1979

1979 – *Portunus neogenicus* Müller; p. 280, Pl. 19
1984 – *Portunus neogenicus* Müller *in* Müller; p. 80, Pl. 62 (figs. 3-4)
1991 – *Portunus neogenicus* Müller *in* Marras & Ventura; p. 110, Pl. 3 (fig. 4)

Holotype: (MAFI).
Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Marras & Ventura (1991) reported one specimen from Sassari (repository and catalogue number unknown).
Note: this species is also reported in the Miocene of Hungary.

Portunus cfr. *P. radobojanus* (Bittner, 1884)

1892c – *Neptunus* aff. *radobojanus* Bittner *in* Ristori; p. 161
1910a – *Neptunus* sp. (*N.* aff. *Radobojanus* Bittner) *in* Fabiani; p. 23
1929 – *Neptunus* cfr. *radobojanus* Bittner *in* Glaessner; p. 269
1996 – *Portunus* aff. *radoboyanus* (Bittner) *in* Beschin, Checchi & Ungaro; p. 16
2001 – *Portunus* (*Portunus*) aff. *radobojanus* (Bittner) *in* De Angeli & Beschin; p. 31

Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: Ristori (1892c) reported four or five specimens from Chiavon (Vicenza) (repository and catalogue number unknown).

Portunus cfr. *P. stenaspis* (Bittner, 1884)

1892c – *Neptunus* aff. *stenaspis* Bittner *in* Ristori; p. 161
1910a – *Neptunus* sp. (*N.* aff. *stenaspis* Bittner) *in* Fabiani; p. 23
1929 – *Neptunus* cf. *stenaspis* Bittner *in* Glaessner; p. 269
1996 – *Portunus* aff. *stenaspis* Bittner *in* Beschin, Checchi & Ungaro; p. 16
2001 – *Portunus* (*Portunus*) aff. *stenaspis* (Bittner) *in* De Angeli & Beschin; p. 31

Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: Ristori (1892c) reported one specimen from Chiavon (Vicenza) (repository and catalogue number unknown).

Portunus suessi (Bittner, 1875)

1875 – *Neptunus Suessi* Bittner; p. 80, Pl. 4 (fig. 1 a-d)
1910a – *Neptunus Suessi* Bittner *in* Fabiani; p. 23
1915 – *Neptunus Suessi* Bittner *in* Fabiani; p. 285
1929 – *Neptunus Suessi* Bittner *in* Glaessner; p. 297
2001 – *Portunus* (*Portunus*) *suessi* (Bittner) *in* De Angeli & Beschin; p. 31

Holotype: unknown
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Bittner (1875) reported this species from Laverda (Vicenza) (repository and catalogue number unknown).

Portunus tuberculatus Roux, 1828

1828 – *Portunus tuberculatus* Roux; Pl. 32 (figs. 1-5)

1914 – *Portunus tuberculatus* Roux *in* M. Gemmellaro; p. 88, Pl. 1 (figs. 22-23)
1929 – *Portunus tuberculatus* Roux *in* Glaessner; p. 336

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported one specimen from Ficarazzi (Palermo) (MGUP, catalogue number unknown).

Portunus vicentinus (A. Milne Edwards, 1860)

1860 – *Neptunus Vicentinus* A. Milne Edwards; p. 238, Pl. 6 (fig. 1 a-b)
1875 – *Neptunus Vicentinus* A. Milne Edwards *in* Bittner; p. 80
1910a – *Neptunus vicentinus* A. Milne Edwards *in* Fabiani; p. 23
1929 – *Neptunus vicentinus* A. Milne Edwards *in* Glaessner; p. 269
1996 – *Potunus vicentinus* (A. Milne Edwards) *in* Beschin, Checchi & Ungaro; p. 16
2001 – *Portunus* (*Portunus*) *vicentinus* (A. Milne Edwards) *in* De Angeli & Beschin; p. 31

Holotype: MNHN R03818.
Stratigraphic range: Tertiary.
Occurrence: Veneto.
Material: A. Milne Edwards (1860) reported one specimen (MNHN R03818) from the "nummulitico" of Vicenza.

Portunus sp.

1892c – *Neptunus* sp. *in* Ristori; p. 161
1929 – *Neptunus* sp. *in* Glaessner; p. 270

Stratigraphic range: Oligocene.
Occurrence: Veneto.
Material: Ristori (1892c) reported some specimens from Chiavon (Vicenza) (repository and catalogue number unknown).

Portunus sp.

1895 – *Portunus* sp. *in* Crema; p. 677
1929 – *Portunus* sp. *in* Glaessner; p. 336

Stratigraphic range: upper Miocene (Tortonian) – upper Pliocene (Piacentian).
Occurrence: Piemonte.
Material: Crema (1895) reported some specimens from Torino and Villavernia (Alessandria), today lost.

Portunus sp.

1909 – *Neptunus* sp. *in* Lörenthey; p. 245

Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported some specimens from Monte S. Michele (Cagliari) (repository and catalogue number unknown).

Portunus sp.

1975 – *Portunus* sp. *in* Secretan; p. 358, Pl. 3

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported one specimen (MSNV M3) from Monte Bolca (Verona).

***Portunus* (*Achelous*)** De Haan, 1833

Type species: *Portunus spinimanus* Latreille, 1819.
Stratigraphic range: Oligocene – Recent.

Portunus (*Achelous*) *obtusus* A. Milne Edwards, 1860

1860 – *Achelous obtusus* A. Milne Edwards; p. 245, Pl. 3 (fig. 2)
1875 – *Achelous obtusus* A. Milne Edwards *in* Bittner; p. 83
1910a – *Achelous obtusus* A. Milne Edwards *in* Fabiani; p. 23
1915 – *Achelous obtusus* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Achelous obtusus* A. Milne Edwards *in* Glaessner; p. 50
2001 – *Portunus* (*Achelous*) *obtusus* A. Milne Edwards *in* De Angeli & Beschin; p. 32

Holotype: MNHN R03807.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: A. Milne Edwards (1860) reported one specimen (MNHN R03807) from Salcedo (Vicenza).

Rakosia Müller, 1984

Type species: *Rakosia carupoides* Müller, 1984.
Stratigraphic range: lower Oligocene (Rupelian) – Miocene.

Rakosia grumiensis Beschin, De Angeli & Checchi, 2001

2001 – *Rakosia grumiensis* Beschin, De Angeli & Checchi; p. 23, Text-fig. 7, Pl. 2 (figs. 3, 6)
2001 – *Rakosia grumiensis* Beschin, De Angeli & Checchi *in* De Angeli & Beschin; p. 31

Holotype: MCZ 2128 (I.G. 286483).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported 31 specimens (MCZ from 2128 to 2150, from 2156 to 2163) from Castelgomberto (Vicenza).

Scylla De Haan, 1833

Type species: *Cancer serratus* Forskål, 1775.
Stratigraphic range: Eocene – Recent.

Scylla sp.

1892 – *Scylla* sp. *in* Ristori; p. 163
1910a – *Scylla* sp. *in* Fabiani; p. 23
1929 – *Scylla* sp. *in* Glaessner; p. 375
2001 – *Scylla* sp. *in* De Angeli & Beschin; p. 32

Stratigraphic range: lower Oligocene (Rupelian).

Occurrence: Veneto.
Material: Ristori (1892c) reported two specimens from Chiavon (Vicenza) (repository and catalogue number unknown).

Indeterminates
Genus et species indeterminate

1998b – Genus et species indeterminate *in* Bravi & Garassino; p. 112, Text-fig. 15

Stratigraphic range: Lower Cretaceous (Albian).
Occurrence: Campania.
Material: Bravi & Garassino (1998b) reported one specimen (M 21840) from Petina (Salerno).

Superfamily Xanthoidea MacLeay, 1838
Family Carpiliidae Ortmann, 1893

Palaeocarpilius A. Milne Edwards, 1862

Type species: *Cancer macrochelus* Desmarest, 1822.
Stratigraphic range: Eocene – Miocene.

Palaeocarpilius aquitanicus A. Milne Edwards, 1862

1847 – *Cancer Boscii in* Burguet; p. 280
1850 – *Cancer Boscii in* d'Archiac; p. 448
1861 – *Cancer Boscii in* Michelotti; p. 139
1862 – *Palaeocarpilius aquitanicus* A. Milne Edwards; p. 57, Pl. 4 (figs. 4, 4 a)
1875 – *Palaeocarpilius platycheilus* (Reuss) *in* Bittner; p. 84, Pl. 3 (fig. 4)
1889 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Ristori; p. 398
1929 – *Palaeocarpilius aquitanicus* A. Milne Edwards *in* Glaessner; p. 292
1974 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Mastrorilli; p. 4
1987 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Allasinaz; p. 541, Pl. 5 (figs. 1-2)
1996 – *Palaeocarpilius macrochelus* (Desmarest) *in* Beschin, Checchi & Ungaro; p. 16, Text-fig. 4, Pl. 2 (figs. 1-2)
2001 – *Palaeocarpilius macrochelus* (Desmarest) *in* Beschin, De Angeli & Checchi; p. 24, Pl. 3 (fig. 1 a-b)
2003 – *Palaeocarpilius aquitanicus* A. Milne Edwards *in* Schweitzer; p. 1112

Holotype: MNHN R03772 (syntype, cast).
Stratigraphic range: Oligocene – Miocene.
Occurrence: Piemonte, Veneto.
Material: Ristori (1889) reported many specimens (*P. macrocheilus*) from Sassello (Savona), housed in don Perrando's collection today in "DIP.TE.RIS" (we identified two original specimens: 2388/Sa-II-S48 (ex Sa-II-S184) and 2390/Sa-II-S187 (ex Sa-II-S184), not figured by the author); Allasinaz (1987) reported one specimen (*P. macrocheilus*) from Ciglione (Ovada) (MCSN, catalogue number unknown); Beschin *et al.* (1996) reported four specimens (*P. macrochelus*, MCZ 1234, 1568, 1569, 1570) from Castelgomberto (Vicenza); Beschin *et al.* (2001) reported three specimens (*P. macrochelus*, MCZ form 2152 to 2154) from Castelgomberto (Vicenza).

Note: this species reported from the lower Oligocene (Rupelian) of N Italy, was usually confused with *P. macrochelus* Desmarest, 1822, which has a carapace with eight rounded lobes and widespread in the levels of the upper Eocene (Beschin *et al.*, 2006). This species is also reported from the lower Oligocene of SW France.

Palaeocarpilius macrochelus (Desmarest, 1822)

Cancer lapidescens Rumphius; p. 84, Pl. 61 (fig. 3)
1622 – *Cancer lapidescens* Rumphius *in* Museum Calceolarianum Veronense; p. 407
Cancer lapidescens Rumphius *in* Aldovrandi (Museum Metallicum); p. 461
1656 – *Cancer lapidescens* Rumphius *in* Museo di Moscardi; p. 179
1822 – *Cancer macrochelus* Desmarest; p. 91, Pl. 7 (figs. 1-2)
1822 – *Cancer Boscii* Desmarest; p. 94, Pl. 8 (figs. 3-4)
1822 – *Brachyurites antiquus* Schlotheim; p. 26, Pl. 1
Cancer antiquus Quenstedt; p. 26, Text-fig. 1
Carpilius macrochelus A. Milne Edwards; p. 380, Pl. 1
1834 – *Cancer boscii* Desmarest *in* A. Milne Edwards; p. 379, Pl. 1, **nov. syn.**
1838 – *Cancer macrochelus* Desmarest *in* Mantell; p. 218, Pl. 25
1854 – *Cancer boscii* Desmarest *in* Catullo; p. 1
1859 – *Atergatis boscii* (Desmarest) *in* Reuss; p. 30, Pl. 9 (figs. 4-9), Pl. 10 (fig. 1), Pl. 11 (figs. 1-4), Pl. 12 (figs. 1-2)
1859 – *Atergatis stenura* Reuss; p. 30, Pl. 11 (figs. 5-7), **nov. syn.**
1859 – *Atergatis platycheilus* Reuss; p. 36, Pl. 10 (figs. 2-3), **nov. syn.**
1862 – *Palaeocarpilius macrocheilus* (Desmarest) *in* A. Milne Edwards; p. 186, Pl. 1 (fig. 2), Pl. 2 (fig. 1), Pl. 3 (fig. 1)
1867 – *Artergatis boscii* (Desmarest) *in* Fraas; p. 300
1875 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Bittner; p. 83
1875 – *Palaeocarpilius stenurus* (Reuss) *in* Bittner; p. 84
1883 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Bittner; p. 311
1883 – *Palaeocarpilius platycheilus* (Reuss) *in* Bittner; p. 311
1885 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Noetling; p. 487, 489, Pl. 4 (fig. 2)
1886 – *Palaeocarpilius macrocheilus* var. *coronata* Bittner; p. 44, Pl. 1 (fig. 1)
1893 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Bittner; p. 20
1895 – *Cancer* (*Palaeocarpilius*) *macrochelus* (Desmarest) *in* De Gregorio; p. 13, Pl. 4 (figs. 1-5)
1895 – *Harpactocarcinus supragigas* De Gregorio; p. 13, Pl. 6 (figs. 1-3), **nov. syn.**
1896 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Vinassa de Regny; p. 127, Pl. 2 (fig. 2 a-b)
1898 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Lörenthey; p. 36
1899 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Oppenheim; p. 59
1901 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Oppenheim; p. 281
1908 – *Palaeoocarpilius macrocheilus* (Desmarest) *in* Fabiani; p. 210, 236
1909 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Lörenthey; p. 132
1910a – *Palaeocarpilius macrocheilus* (Desmarest) *in* Fabiani; p. 24
1915 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Fabiani; p. 284, 285
1915 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Dainelli; p. 699
1929 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Glaessner; p. 292
1944 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Checchia-Rispoli; p. 109
1946 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Stubblefield; p. 513, Pl. 8 (figs. 2-6)

1953 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Roger; p. 359, Pl. 2 (fig. 1)
1962 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Piccoli & Mocellini; p. 38, 48, 78
1969 – *Palaeocarpilius macrochelus* (Desmarest) *in* Glaessner; p. 520, Text-fig. 328 (1)
1969 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Via Boada; p. 403
1995 – *Palaeocarpilius macrochelus* (Desmarest) *in* De Angeli; p. 16
2001 – *Palaeocarpilius macrochelus* (Desmarest) *in* De Angeli & Beschin; p. 32, Text-fig. 27
2003 – *Palaeocarpilius macrocheilus* (Desmarest) *in* Schweitzer; p. 1112
2004 – *Palaeocarpilius macrochelus* (Desmarest) *in* Beschin & De Angeli; p. 20
2006 – *Palaeocarpilius macrochelus* (Desmarest) *in* Beschin, De Angeli, Checchi & Mietto; p. 107, Pl. 3 (figs. 3, 4 a-b)

Holotype: MNHN R03830.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Desmarest (1822) reported one specimen (MNHN R03830) from China?, but probably discovered in the "nummulitico" of Verona; A. Milne Edwards (1862-1865) reported four specimens (MNHN R03814, R03829, R03830, A24548) without pointing out the fossiliferous localities, probably discovered in the "nummulitico" of Verona; Vinassa de Regny (1896) reported one specimen from Avesa (Verona) (repository and catalogue number unknown); Reuss (1859), Bittner (1886), and Fabiani (1910a) reported this specimens from some localities of Veneto (repository and catalogue number unknown); De Gregorio (1895) reported three specimens from Valrovina (Vicenza) (repository and catalogue number unknown), and one specimen from Verona (MGV, catalogue number unknown); Dainelli (1915) reported two specimens from Monte Plauris (Udine) (repository and catalogue number unknown); Piccoli & Mocellin (1962) reported one specimen from Priabona-Monte di Malo (Vicenza) (MGPD, catalogue number unknown); De Angeli (1995) reported one specimen from "Fontanella" di Grancona (Vicenza) (MCZ, catalogue number unknown); Beschin *et al.* (2006) reported five specimens (MCZ 1191, 1235, 1327, 2445, 1446) from Grotta della Poscola, Buso della Rana, and Val Segato (Vicenza).
Note: the study of some carapaces from the Oligocene of Vicenza area and Bacino Ligure-Piemontese has pointed out the presence of seven anterolateral lobes instead of eight, as reported for the specimens of *P. macrochelus*, discovered in the levels of the upper Eocene. The presence of seven alterolateral lobes is typical of *P. aquitanicus* A. Milne Edwards, 1862, reported from the levels of the lower Oligocene (Rupelian) of France. *Palaeocarpilius macrochelus* is also reported from the Eocene of Hungary, France, Egypt, and Somalia.

Palaeocarpilus simplex Stoliczka, 1871

1871 – *Palaeocarpilius simplex* Stoliczka; p. 11, Pl. 5 (fig. 6)
1875 – *Palaeocarpilius anodon* Bittner; p. 85, Pl. 2 (fig. 3), **nov. syn.**
1909 – *Palaeocarpilius simplex* Stoliczka *in* Lörenthey; p. 127, Pl. 1 (figs. 3-4)
1910a – *Palaeocarpilius anodon* Bittner *in* Fabiani; p. 24
1915 – *Palaeocarpilius anodon* Bittner *in* Fabiani; p. 284
1929 – *Palaeocarpilius simplex* Stoliczka *in* Glaessner; p. 294
1933 – *Palaeocarpilius anodon* Bittner *in* Di Salvo; p. 18, Pl. 1 (fig. 1 a-c)
1959 – *Palaeocarpilius simplex* Stoliczka *in* Via Boada; p. 380
1969 – *Palaeocarpilius simplex* Stoliczka *in* Via Boada; p. 231, Pl. 23 (figs. 3-4)
1982 – *Palaeocarpilius anodon* Bittner *in* Busulini, Tessier & Visentin; p. 81
1994 – *Palaeocarpilius simplex* Stoliczka *in* Beschin, Busulini, De Angeli & Tessier; p. 187, Pl. 9 (fig. 1 a-b)
2001 – *Palaeocarpilius simplex* Stoliczka *in* De Angeli & Beschin; p. 33
2003 – *Palaeocarpilius simplex* Stoliczka *in* Schweitzer; p. 1112
2003 – *Palaeocarpilius anodon* Bittner *in* Schweitzer; p. 1112
2004 – *Palaeocarpilius simplex* Stoliczka *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2004 – *Palaeocarpilius simplex* Stoliczka *in* Beschin & De Angeli; p. 20
2005 – *Palaeocarpilius simplex* Stoliczka *in* Beschin, De Angeli, Checchi & Zarantonello; p. 23, Pl. 4 (fig. 9)

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto, Sicilia.
Material: Bittner (1875) reported one specimen from S. Giovanni Ilarione (Verona) (type of *P. anodon* Bittner, 1875 = MNHB K.111, MB.A. 661); Di Salvo (1933) reported one specimen from Ponte di Castronuovo (Palermo) housed in Di Salvo's collection (repository and catalogue number unknown); Busulini *et al.* (1982) reported six specimens from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1994) reported one specimen (MCZ 1205) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2005) reported five specimens (MCZ 2302, 2303, 2324; MV 48, 04/17) from Grola di Cornedo Vicentino (Vicenza).
Note: this species is also reported from the Eocene of Pakistan, Egypt, and Spain.

Palaeocarpilius valrovinensis (De Gregorio, 1895)

1895 – *Cancer* (*Harpactocarcinus*) *Valrovinensis* De Gregorio; p. 12, Pl. 5 (figs. 1-4)
1910a – *Harpactocarcinus valrovinensis* De Gregorio *in* Fabiani; p. 26
1915 – *Harpactocarcinus valrovinensis* De Gregorio *in* Fabiani; p. 285
1929 – *Harpactocarcinus valrovinensis* De Gregorio *in* Glaessner; p. 206
2003 – *Palaeocarpilius valrovinensis* (De Gregorio) *in* Schweitzer; p. 1119

Holotype: unknown.
Stratigraphic range: Eocene (Lutetian).
Occurrence: Veneto.
Material: De Gregorio (1895) reported one specimen from Valrovina (Vicenza) (repository and catalogue number unknown).

Family Domeciidae Ortmann, 1893

Jonesius Sankarankutty, 1962

Type species: *Jonesius minuta* Sankarankutty, 1962.

Stratigraphic range: Oligocene – Recent.

Jonesius oligocenicus (Beschin, De Angeli & Checchi, 2001)

2001 – *Maldivia oligocenica* Beschin, De Angeli & Checchi; p. 24, Text-fig. 8, Pl. 3 (fig. 2)
2001 – *Maldivia oligocenica* Beschin, De Angeli & Checchi *in* De Angeli & Beschin; p. 37
2004 – *Maldivia oligocenica* Beschin, De Angeli & Checchi *in* Beschin & De Angeli; p. 21
2005 – *Jonesius oligocenicus* (Beschin, De Angeli, Checchi) *in* Schweitzer; p. 626

Holotype: MCZ 2121 (I.G. 286476).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported three specimens (MCZ 2121, 2164, 2165) from Castelgomberto (Vicenza).

Family Goneplacidae MacLeay, 1838

Branchioplax Rathbun, 1916

Type species: *Branchioplax washingtoniana* Rathbun, 1916.
Stratigraphic range: Eocene.

Branchioplax albertii De Angeli & Beschin, 2002

2002 – *Branchioplax albertii* De Angeli & Beschin; p. 126, Text-figs. 2-3
2004 – *Branchioplax albertii* De Angeli & Beschin *in* Beschin & De Angeli; p. 21
2006 – *Branchioplax albertii* De Angeli & Beschin *in* Beschin, De Angeli, Checchi & Mietto; p. 108, Pl. 3 (figs. 1-2)

Holotype: MCZ 2062 (I.G. 286340).
Stratigraphic range: middle Eocene (Lutetian) – upper Eocene (Priabonian).
Occurrence: Veneto.
Material: De Angeli & Beschin (2002) reported two specimens (MCZ 2062, 2063) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2006) reported four specimens (MCZ 1328, from 2447 to 2449) from Buso della Rana (Vicenza).

Chlinocephalus Ristori, 1886

Type species: *Chlinocephalus demissifrons* Ristori, 1886.
Stratigraphic range: Pliocene.

Chlinocephalus demissifrons Ristori, 1886

1886 – *Chlinocephalus demissifrons* Ristori; p. 101, Pl. 2 (figs. 5-6)
1891a – *Titanocarcinus sculptus* Ristori; p. 6, Pl. 1 (figs. 1-2), **nov. syn.**
1929 – *Chlinocephalus demissifrons* Ristori *in* Glaessner; p. 113
1981 – *Chlinocephalus demissifrons* Ristori *in* Delle Cave; p. 46
2004 – *Chlinocephalus demissifrons* Ristori *in* Garassino, De Angeli, Gallo & Pasini; p. 275, Text-figs. 15-16

Syntype: IGF 628E (figured by Ristori in Pl. 2, figs. 5-6).
Stratigraphic range: Pliocene.
Occurrence: Liguria, Piemonte.
Material: Ristori (1886) reported one specimen from Fornaci (Savona) today lost; Garassino *et al.* (2004) reported one specimen (PU 41187) from Cossato (Biella).
Note: Garassino *et al.* (2004) pointed out that the assignment of *Titanocarcinus sculptus* Ristori, 1891, from the Pliocene clays of Mucigliani (Siena – Toscana) to *Titanocarcinus* A. Milne Edwards, 1863, is uncertain. In fact, the shape of the front, the size and location of the orbits, the presence of two spines besides the extraorbital spine on anterolateral margins, and the transverse relief on the cardiac region are present also in *Chlinocephalus demissifrons*. The specimen of *T. sculptus* studied by Ristori (1891a) could be a juvenile stage (maximum width of carapace = 2 mm; maximum length of carapace = 1.5 mm) of *Chlinocephalus demissifrons*. The specimen studied by Ristori (1891a) is housed in the Museo dei Fisiocritici di Siena (MFS 4624).

Corallicarcinus Müller & Collins, 1991

Type species: *Neptocarcinus spinosus* Lörenthey, 1929.
Stratigraphic range: upper Eocene – lower Oligocene.

Corallicarcinus sp.

2001 – *Corallicarcinus* sp. *in* Beschin, De Angeli & Checchi; p. 26, Pl. 3 (fig. 3)
2001 – *Corallicarcinus* sp. *in* De Angeli & Beschin; p. 37
2004 – *Corallicarcinus* sp. *in* Beschin & De Angeli; p. 21

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported one specimen (MCZ 2127) from Castelgomberto (Vicenza).

Gollincarcinus Beschin & De Angeli, 2004

Type species: *Gollincarcinus levis* Beschin & De Angeli, 2004.
Stratigraphic range: middle Eocene (Lutetian).

Gollincarcinus levis Beschin & De Angeli, 2004

2004 – *Gollincarcinus levis* Beschin & De Angeli; p. 15, Text-fig. 2, Pl. 1 (figs. 1-2, 3 a-e)
2005 – *Gollincarcinus levis* Beschin & De Angeli *in* Beschin, De Angeli, Checchi & Zarantonello; p. 26, Pl. 5 (fig. 4 a-b)

Holotype: MCZ 2405 (I.G. 305113).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin & De Angeli (2004) reported five specimens (MCZ 2305, 2405, 2406, 2407, 2408) from "Main" quarry of Arzignano (Vicenza), "Boschetto" quarry of Nogarole Vicentino (Vicenza), and Grola di Cornedo Vicentino (Vicenza); Beschin *et al.* (2005)

reported one specimen (MCZ 2305) from Grola di Cornedo Vicentino (Vicenza).

Goneplax Leach, 1814

Type species: *Cancer rhomboides* Linnaeus, 1758.
Stratigraphic range: Miocene – Recent.

Goneplax gulderi Bachmayer, 1953

1895 – *Goneplax sacci* Crema; p. 674, Text-fig. 15, **nov. syn.**
1907 – *Goneplax* cfr. *sacci* Crema *in* Lörenthey; p. 94, Pl. 3 (figs. 4 a-c, 6-7), Pl. 4 (fig. 6)
1909 – *Goneplax* cfr. *sacci* Crema *in* Lörenthey; p. 249, Pl. 1 (fig. 4 a-c, 6-7), Pl. 2 (fig. 6)
1929 – *Goneplax saccoi* Crema *in* Glaessner; p. 199
1948 – *Goneplax* cfr. *saccoi* Crema *in* Via Boada; p. 146, Pl. 1 (fig. 6)
1953 – *Goneplax gulderi* Bachmayer; p. 143, Pl. 9 (figs. 1-3)
1984 – *Goneplax gulderi* Bachmayer *in* Müller; p. 96, Pl. 93 (figs. 2-3)
1988 – *Goneplax* cf. *saccoi* Crema *in* Solé & Via Boada; p. 34
1993 – *Goneplax gulderi* Bachmayer *in* Müller; p. 23, Text-fig. 11 K
1998 – *Goneplax gulderi* Bachmayer *in* Mayoral, Müller & Muñiz; p. 508, Text-fig. 2 (5)
1998 – *Goneplax gulderi* Bachmayer *in* Müller; p. 38
2004a – *Goneplax gulderi* Bachmayer *in* Garassino & De Angeli; p. 45

Holotype: unknown.
Stratigraphic range: Miocene – Pliocene.
Occurrence: Piemonte, Sardegna.
Material: Crema (1895) reported one specimen from Monte Capriolo (Bra – Cuneo), today lost; Lörenthey (1909) reported some specimens from Capo S. Marco (Cagliari), housed in Lovisato' collection (repository and catalogue number unknown).
Note: Müller (1993) pointed out that *Goneplax sacci* Crema, 1895, and *G.* cfr. *G. sacci* described by Lörenthey (1907, 1909) are synonyms of *G. gulderi* Bachmayer, 1953. This species is also reported from the Miocene of Austria, Spain and Hungary.

Goneplax rhomboides (Linnaeus, 1758)

1758 – *Cancer rhomboides* Linnaeus; p. 626
1814 – *Goneplax angulata* (Bell) *in* Leach; p. 430
1816 – *Gonoplax bispinosa* Leach; p. 420, **nov. syn.**
1822 – *Goneplax impressa* Desmarest; p. 102, Pl. 8 (figs. 13-14), **nov. syn.**
1861 – *Goneplax rhomboides* (Linnaeus) *in* A. Milne Edwards; p. 88
1863 – *Gonoplax angulata* (Bell) *in* Heller; p. 103
1863 – *Gonoplax rhomboides* (Linnaeus) *in* Heller; p. 104, Pl. 3 (figs. 3-4)
1886 – *Goneplax impressa* Desmarest *in* Ristori; p. 111
1886 – *Goneplax formosa* Ristori; p. 111, Pl. 3 (figs. 11-13), **nov. syn.**
1886 – *Goneplax meneghinii* Ristori; p. 114, Pl. 3 (figs. 8-10), **nov. syn.**
1891b – *Gonoplax bispinosa* Leach *in* Ristori; p. 20
1892a – *Gonoplax meneghinii* Ristori *in* Ristori; p. 89
1896 – *Gonoplax meneghinii* Ristori *in* Ristori; p. 506
1896 – *Gonoplax rhomboides* (Linnaeus) *in* Caullery; p. 405
1914 – *Gonoplax* cfr. *rhomboides* (Linnaeus) *in* M. Gemmellaro; p. 90, Pl. 1 (fig. 26)
1918 – *Gonoplax angulata* Heller *in* Pesta; p. 436, Text-fig. 144 a-b
1923 – *Goneplax meneghini*? Ristori *in* Tettoni; p. 161
1929 – *Goneplax rhomboides* (Linnaeus) *in* Glaessner; p. 199
1929 – *Goneplax formosa* Ristori *in* Glaessner; p. 198
1929 – *Goneplax meneghinii* Ristori *in* Glaessner; p. 199
1933 – *Goneplax angulata* (Bell) *in* de Miranda; p. 54
1936 – *Goneplax angulata* (Bell) *in* Nobre; p. 57, Pl. 21 (fig. 40)
1940 – *Goneplax angulata* (Bell) *in* de Miranda; p. 29
1940 – *Goneplax angulata* (Bell) *in* Bouvier; p. 278, Text-fig. 176, Pl. 9 (fig. 2)
1946 – *Goneplax angulata* (Bell) *in* Zariquiey Alvarez; p. 162, Pl. 18 (a-b)
1958 – *Goneplax rhomboides* (Linnaeus) *in* Holthuis & Gottlieb; p. 99
1959 – *Goneplax rhomboides* (Linnaeus) *in* Zariquiey Alvarez; p. 5
1961 – *Goneplax rhomboides* (Linnaeus) *in* Holthuis; p. 57
1961 – *Goneplax angulata* (Bell) *in* Nunes-Ruivo; p. 28
1968 – *Goneplax rhomboides* (Linnaeus) *in* Zariquiey Alvarez; p. 414, Text-figs. 1 e, 138 a-b
1981 – *Goneplax formosa* (Linnaeus) *in* Delle Cave; p. 48
1992 – *Goneplax rhomboides* (Linnaeus) *in* Falciai & Minervini; p. 238, Pl. 27 (fig.1)
2004a – *Goneplax rhomboides* (Linnaeus) *in* Garassino & De Angeli; p. 44, Text-figs. 12-15
2004 – *Goneplax rhomboides* (Linnaeus) *in* Garassino, De Angeli, Gallo & Pasini; p. 274, Text-fig. 14

Holotype: unknown.
Stratigraphic range: Pliocene – Pleistocene.
Occurrence: Piemonte, Emilia Romagna, Toscana, Lazio, Sicilia.
Material: Desmarest (1822) reported some specimens from Monte Mario (Roma) (repository and catalogue number unknown); A. Milne Edwards (1861) reported some specimens from Palermo (repository and catalogue number unknown); Ristori (1886) reported four specimens from Rapolano (Siena) (IGF, catalogue number unknown); Ristori (1891b) reported one specimen from Monte Mario (Roma), housed in Zuccari's collection (MGPUR, catalogue number unknown); M. Gemmellaro (1914) reported one specimen from Ficarazzi (Palermo) (MGUP, catalogue number unknown); Tettoni (1923) reported some specimens from S. Venanzio (Modena) (MGUM, catalogue number unknown); Garassino & De Angeli (2004a) reported 13 specimens (MG 0566, from 0596 to 0600, 0601, 0602, 0612, 0614, 0621, 0632, 0633) from Fiume Arda, Fiume Enza, and Torrente Stirone (Piacenza and Parma); Garassino *et al.* (2004) reported two specimens (PU 41185, PU 41186) from Cocconato (Asti) and Cossato (Biella).
Note: Müller (1993) pointed out that *Goneplax formosa* Ristori, 1886 (holotype, IGF 612E, figured by Ristori in Pl. 3, figs. 11-13) and *G. meneghinii* Ristori, 1886 (syntypes, IGF 609E, figured by Ristori in Pl. 3, fig. 10; 610E, figured by Ristori in Pl. 3, figs. 8, 9, 9 a; 611E not figured) both from Rapolano (Siena) are synonyms of *G. rhomboides* (Linnaeus, 1758). The specimens of these species are housed in the Museo di Geologia e Paleontologia dell'Università di Firenze. This species is also reported from the upper Pliocene of Great Britain.

Lessinioplax Beschin & De Angeli, 2004

Type species: *Lessinioplax simplex* Beschin & De Angeli, 2004.
Stratigraphic range: middle Eocene (Lutetian).

Lessinioplax rugosa Beschin & De Angeli, 2004

2004 – *Lessinioplax rugosa* Beschin & De Angeli; p. 20, Text-fig. 4, Pl. 2 (figs. 2 a-b, 3)

Holotype: MCZ 1175 (I.G. 211690).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin & De Angeli (2004) reported two specimens (MCZ 1175, 2414) from "Albanello" quarry of Nogarole Vicentino (Vicenza).

Lessinioplax simplex Beschin & De Angeli, 2004

2004 – *Lessinioplax simplex* Beschin & De Angeli; p. 18, Text-fig. 3, Pl. 2 (figs. 1 a-c, 4 a-c)

Holotype: MCZ 2409 (I.G. 305117).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin & De Angeli (2004) reported five specimens (MCZ 2409, 2410, 2411, 2412, 2413) from "Main" quarry of Arzignano (Vicenza).

Magyarcarcinus Schweitzer & Karasawa, 2004

Type species: *Palaeograpsus lóczyanus* Lörenthey, 1897.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).

Magyarcarcinus loczyanus (Lörenthey, 1897)

1897 – *Palaeograpsus lóczyanus* Lörenthey; p. 157, 168
1898 – *Palaeograpsus lóczyanus* Lörenthey *in* Lörenthey; p. 69, Pl. 4 (fig. 6)
1929 – *Palaeograpsus lóczyanus* Lörenthey *in* Glaessner; p. 296
1929 – *Palaeograpsus lóczyanus* Lörenthey *in* Lörenthey & Beurlen; p. 255, Pl. 16 (fig. 1 a-e)
1994 – *Palaeograpsus lóczyanus* Lörenthey *in* Beschin, Busulini, De Angeli & Tessier; p. 196, Pl. 11 (figs. 1-3)
1998 – *Palaeograpsus loczyanus* Lörenthey *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 31, figs. 15 (3), 16 (2)
2000 – *Palaeograpsus loczyanus* Lörenthey *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Palaeograpsus loczyanus* Lörenthey *in* De Angeli & Beschin; p. 38, Text-fig. 33
2001 – *Carcinoplax loczyanus* (Lörenthey) *in* Karasawa & Kato; p. 272
2004 – *Magyarcarcinus loczyanus* (Lörenthey) *in* Schweitzer & Karasawa; p. 76, Text-fig. 1 (3-5)
2004 – *Magyarcarcinus loczyanus* (Lörenthey) *in* Beschin & De Angeli; p. 21
2005 – *Magyarcarcinus loczyanus* (Lörenthey) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 26

Holotype: MAFI E282, E283.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported six specimens (MCZ 1213, 1216, from 1417 to 1419, 1441) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (1998) reported four specimens (MCZ from 1517 to 1520) from "Rossi" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Maingrapsus Tessier, Beschin, Busulini & De Angeli, 1999

Type species: *Maingrapsus quadratus* Tessier, Beschin, Busulini & De Angeli, 1999.
Stratigraphic range: middle Eocene (Lutetian).

Maingrapsus quadratus Tessier, Beschin, Busulini & De Angeli, 1999

1999 – *Maingrapsus quadratus* Tessier, Beschin, Busulini & De Angeli; p. 98, Text-fig. 3, Pl. 2 (figs. 1-3)
2001 – *Maingrapsus quadratus* Tessier, Beschin, Busulini & De Angeli *in* De Angeli & Beschin; p. 38
2001 – *Maingrapsus quadratus* Tessier, Beschin, Busulini & De Angeli *in* Karasawa & Kato; p. 272
2004 – *Maingrapsus quadratus* Tessier, Beschin, Busulini & De Angeli *in* Beschin & De Angeli; p. 21
2004 – *Maingrapsus quadratus* Tessier, Beschin, Busulini & De Angeli *in* Beschin, Busulini, De Angeli & Tessier; p. 116

Holotype: MCZ 1613 (I.G. 284680).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Tessier *et al.* (1999) reported five specimens (MCZ 1591, from 1601 to 1603, 1613) from "Main" quarry of Arzignano (Vicenza).
Note: Karasawa & Kato (2001) suggested the ascription of this genus to the family Goneplacidae.

Paracorallicarcinus Tessier, Beschin, Busulini & De Angeli, 1999

Type species: *Paracorallicarcinus arcanus* Tessier, Beschin, Busulini & De Angeli, 1999.
Stratigraphic range: middle Eocene (Lutetian).

Paracorallicarcinus arcanus Tessier, Beschin, Busulini & De Angeli, 1999

1999 – *Paracorallicarcinus arcanus* Tessier, Beschin, Busulini & De Angeli; p. 95, Text-fig. 2, Pl. 1 (figs. 1-3)
2001 – *Paracorallicarcinus arcanus* Tessier, Beschin, Busulini & De Angeli *in* De Angeli & Beschin; p. 38, Text-fig. 32
2004 – *Paracorallicarcinus arcanus* Tessier, Beschin, Busulini & De Angeli *in* Beschin & De Angeli; p. 21

Holotype: MCZ 1595 (I.G. 284662).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Tessier *et al.* (1999) reported 14 specimens (MCZ from 1584 to 1590, from 1592 to 1598) from "Main" quarry of Arzignano (Vicenza).

Simonellia Vinassa de Regny, 1897

Type species: *Simonellia quiricensis* Vinassa de Regny, 1897.
Stratigraphic range: Pliocene.

Simonellia quiricensis Vinassa de Regny, 1897

1897 – *Simonellia quiricensis* Vinassa de Regny; p. 2, Pl. 2 (fig. 1)
1929 – *Simonellia quiricensis* Vinassa de Regny *in* Glaessner; p. 378
1969 – *Simonellia quiricensis* Vinassa de Regny *in* Glaessner; p. 521

Holotype: lost.
Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Vinassa de Regny (1897) reported one specimen from S. Quirico d'Orcia (Siena), today lost.
Note: Glaessner (1929) ascribed *Simonellia* in dubitative form to the family Goneplacidae. Later Glaessner (1969) included this genus in the family Xanthidae, pointing out that it differs from *Chlinocephalus* in flat smooth carapace, shape of sternum, and abdomen, and from *Quadrella* in shorter anterolateral margin and front.

Family Hexapodidae Miers, 1886

Stevea Manning & Holthuis, 1981

Type species: *Hexapus williamsi* Glassell, 1938.
Stratigraphic range: middle Eocene (Lutetian) – Recent.

Stevea cesarii Beschin, Busulini, De Angeli & Tessier, 1994

1994 – *Stevea cesarii* Beschin, Busulini, De Angeli & Tessier; p. 192, Text-fig. 8, Pl. 10 (figs. 1-5)
2001 – *Stevea cesarii* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 38
2004 – *Stevea cesarii* Beschin, Busulini, De Angeli & Tessier *in* Beschin & De Angeli; p. 21
2006 – *Stevea cesarii* Beschin, Busulini, De Angeli & Tessier *in* Guinot; p. 560, 567

Holotype: MCZ 1452 (I.G. 286326).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported six specimens (MCZ 1176, 1430, from 1451 to 1454) from "Albanello" and "Boschetto" quarries of Nogarole Vicentino (Vicenza).

Family Menippidae Ortmann, 1893

Eriphia Latreille, 1817

Type species: *Cancer spinifrons* Herbst, 1782.
Stratigraphic range: Oligocene – Recent.

Eriphia cocchii Ristori, 1886

1886 – *Eriphia cocchii* Ristori; p. 105, Pl. 2 (figs. 3, 4, 11, 13), Pl. 3 (figs. 1-2)
1886 – *Eriphia punctulata* Ristori; p. 109, Pl. 2 (figs. 2, 15-16), **nov. syn.**
1891a – *Eriphia punctulata* Ristori *in* Ristori; p. 9
1910 – *Eriphia cocchii* Ristori *in* Fucini; p. 3, Text-figs. 1 a-c, 2
1929 – *Eriphia cocchii* Ristori *in* Glaessner; p. 149
1981 – *Eriphia cocchii* Ristori *in* Delle Cave; p. 46
1981 – *Eriphia punctulata* Ristori *in* Delle Cave; p. 47

Syntypes: IGF 617E (figured by Ristori in Pl. 2, figs. 3, 4, 13, 14); IGF 868E (figured by Ristori in Pl. 3, figs. 1-2); IGF 869E and IGF 870E (not figured by Ristori).
Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1886) reported three specimens from Montrappoli Val d'Era and Montebicchieri (S. Miniato al Tedesco) (IGF); Ristori (1891a) reported one specimen from Poggio all'Olio (Empoli) (IGF); Fucini (1910) reported one specimen from Spicchio (Empoli) (MSNTC, catalogue number unknown).
Note: Ristori (1886) reported one specimen from Montrappoli Val d'Era, ascribing it to *E. punctulata* (holotype: IGF 614E, figured by Ristori in Pl. 2, figs. 2, 14-15), today synonym of *E. cocchii*.

Eriphia spinifrons (Herbst, 1782)

1782 – *Cancer spinifrons* Herbst; p. 185, Pl. 11 (fig. 65)
1816 – *Eriphia spinifrons* (Herbst) *in* Risso; p. 13
1825 – *Eriphia spinifrons* (Herbst) *in* Desmarest; p. 126, Pl. 14 (fig. 1)
1829 – *Eriphia spinifrons* (Herbst) *in* Holl; p. 145
1865 – *Cancer spinifrons* Herbst *in* A. Milne Edwards; p. 305
1885 – *Eriphia spinifrons* (Herbst) *in* Carus; p. 514
1911 – *Eriphia spinifrons* (Herbst) *in* Magrì; p. 13
1914 – *Eriphia spinifrons* (Herbst) *in* M. Gemmellaro; p. 87, Pl. 1 (fig. 21)
1929 – *Eriphia spinifrons* (Herbst) *in* Glaessner; p. 149
1971 – *Eriphia spinifrons* (Herbst) *in* Philippe & Secretan; p. 12, Pl. B (figs. 10-11)

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported some specimens from Monte Pellegrino, Ficarazzi, and Bagheria (Palermo) housed in Marchese di Monterosato's collection (repository and catalogue number unknown) and MGUP (catalogue number unknown).
Note: this species is also reported from the Miocene of France.

Eriphia sp.

1846 – *Eriphia* sp. *in* E. Sismonda; p. 69, Pl. 3 (fig. 6)
1929 – *Eriphia* sp. *in* Glaessner; p. 150

Stratigraphic range: middle Miocene (Helvetian).
Occurrence: Piemonte.
Material: E. Sismonda (1846) reported one specimen from Torino (repository and catalogue number unknown).

Eriphia sp.

1888 – *Eriphia* sp. *in* Ristori; p. 215
1929 – *Eriphia* sp. *in* Glaessner; p. 150

Stratigraphic range: Miocene.
Occurrence: Toscana.

Material: Ristori (1888) reported this genus from S. Benedetto in Val Benedetta (Livorno), today lost.

Eriphia sp.

1889 – *Eriphia* sp. *in* Ristori; p. 400
1929 – *Eriphia* sp. *in* Glaessner; p. 150
1974 – *Eriphia* sp. *in* Mastrorilli; p. 4

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Piemonte.
Material: Ristori (1889) reported two specimens from Mioglia (Savona), today lost.

Eriphia sp.

1895 – *Eriphia* sp. *in* Crema; p. 677
1929 – *Eriphia* sp. *in* Glaessner; p. 150

Stratigraphic range: Miocene.
Occurrence: Piemonte.
Material: Crema (1895) reported many specimens from Torino, today lost.

Eriphia sp.

1975 – *Eriphia* sp. *in* Secretan; p. 362, Text-fig. 20, Pl. 23 (fig. 1)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported one specimen (MSNV 4) from Monte Bolca (Verona).

Eriphia sp.

2004 – *Eriphia* sp. *in* Garassino, De Angeli, Gallo & Pasini; p. 271, Text-fig. 12 a-b

Stratigraphic range: Pliocene.
Occurrence: Piemonte.
Material: Garassino *et al.* (2004) reported one specimen (PU 41180) from Orta San Giulio (Novara).

Family Panopeidae Ortmann, 1893

Bittneria Schweitzer & Karasawa, 2004

Type species: *Palaeograpsus attenuatus* Bittner, 1875.
Stratigraphic range: middle Eocene (Lutetian).

Bittneria attenuatus (Bittner, 1875)

1875 – *Palaeograpsus attenuatus* Bittner; p. 100, Pl. 2 (fig. 10 a-b)
1910a – *Palaeograpsus attenuatus* Bittner *in* Fabiani; p. 28
1915 – *Palaeograpsus attenuatus* Bittner *in* Fabiani; p. 285
1929 – *Palaeograpsus attenuatus* Bittner *in* Glaessner; p. 295
1994 – *Palaeograpsus attenuatus* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 195, Pl. 9 (fig. 4)
2001 – *Palaeograpsus attenuatus* Bittner *in* De Angeli & Beschin; p. 38
2004 – *Bittneria attenuatus* (Bittner) *in* Schweitzer & Karasawa; p. 80, Text-fig. 1 (6)
2004 – *Bittneria attenuatus* (Bittner) *in* Beschin & De Angeli; p. 21

Holotype: MNHB MB.A. 663.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875) reported one specimen (MNHB MB.A. 663) from S. Giovanni Ilarione (Verona); Beschin *et al.* (1994) reported three specimens (MCZ from 1422 to 1424) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).

Carinocarcinus Lörenthey, 1898

Type species: *Carinocarcinus zitteli* Lörenthey, 1898.
Stratigraphic range: middle Eocene (Lutetian).

Carinocarcinus zitteli Lörenthey, 1898

1898 – *Carinocarcinus Zitteli* Lörenthey; p. 138, Pl. 10 (fig. 1)
1925 – *Carinocarcinus Zitteli* Lörenthey *in* Schlosser; p. 143
1929 – *Carinocarcinus Zitteli* Lörenthey *in* Glaessner; p. 112
1939 – *Carinocarcinus Zitteli* Lörenthey *in* Vecsey; p. 37, Text-figs. 5-6
1969 – *Carinocarcinus zitteli* Lörenthey *in* Via Boada; p. 369
1969 – *Carinocarcinus zitteli* Lörenthey *in* Glaessner; p. 526, Text-fig. 333 (7)
2005 – *Carinocarcinus zitteli* Lörenthey *in* Beschin, De Angeli, Checchi & Zarantonello; p. 26, Text-fig. 17, Pl. 5 (figs. 1, 5)

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported two specimens (MV 44, 04/17) from Grola di Cornedo Vicentino (Vicenza).
Note: this species is also reported from middle Eocene of Germany and Hungary.

Glyphithyreus Reuss, 1859

Type species: *Glyphithyreus wetherelli* Bell, 1858.
Stratigraphic range: Paleocene – Oligocene.

Glyphithyreus ellipticus (Bittner, 1875)

1875 – *Plagiolophus ellipticus* Bittner; p. 96, Pl. 2 (fig. 8 a-b)
1897 – *Plagiolophus ellipticus* Bittner *in* Oppenheim; p. 210
1910a – *Plagiolophus ellipticus* Bittner *in* Fabiani; p. 26
1915 – *Plagiolophus ellipticus* Bittner *in* Fabiani; p. 285
1929 – *Plagiolophus ellipticus* Bittner *in* Glaessner; p. 329
2001 – *Glyphithyreus ellipticus* (Bittner) *in* De Angeli & Beschin; p. 37
2004 – *Glyphithyreus ellipticus* (Bittner) *in* Beschin & De Angeli; p. 21

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875) reported this species from Brusaferri of Bolca (Verona) (repository and catalogue number unknown).

Lophopanopeus Rathbun, 1898

Type species: *Xantho bella* Stimpson, 1860.
Stratigraphic range: middle Eocene (Lutetian) – Recent.

Lophopanopeus sp.

1998 – *Lophopanopeus* sp. *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 28, Text-figs. 14-15 (2)
2000 – *Lophopanopeus* sp. *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Lophopanopeus* sp. *in* De Angeli & Beschin; p. 36
2004 – *Lophopanopeus* sp. *in* Beschin & De Angeli; p. 21

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1998) reported one specimen (MCZ 1540) from "Rossi" quarry of Monte di Malo (Vicenza).

Palaeograpsus Bittner, 1875

Type species: *Paleograpsus inflatus* Bittner, 1875.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).

Palaeograpsus inflatus Bittner, 1875

1875 – *Palaeograpsus inflatus* Bittner; p. 100, Pl. 2 (fig. 11 a-b)
1910a – *Palaeograpsus inflatus* Bittner *in* Fabiani; p. 12, 28, Pl. 2 (figs. 5-6)
1915 – *Palaeograpsus inflatus* Bittner *in* Fabiani; p. 285
1929 – *Palaeograpsus inflatus* Bittner *in* Glaessner; p. 295
1929 – *Palaeograpsus inflatus* Bittner *in* Lörenthey & Beurlen; p. 254, Pl. 16 (fig. 2)
1994 – *Palaeograpsus inflatus* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 194, Pl. 9 (fig. 5)
1995 – *Palaeograpsus inflatus* Bittner *in* De Angeli; p. 16, Text-fig. 3 (2-3), Pl. 2 (figs. 2-4)
1998 – *Palaeograpsus inflatus* Bittner *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 30, Text-fig. 16 (1)
2000 – *Palaeograpsus inflatus* Bittner *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Palaeograpsus inflatus* Bittner *in* De Angeli & Beschin; p. 38
2001 – *Palaeograpsus inflatus* Bittner *in* Karasawa & Kato; p. 272
2004 – *Palaeograpsus inflatus* Bittner *in* Beschin & De Angeli; p. 21
2004 – *Palaeograpsus inflatus* Bittner *in* Schweitzer & Karasawa; p. 80

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian) – upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Bittner (1875) reported this species from Laverda (Vicenza) and Fumane di Polesella (Verona) without stratigraphic indication (repository and catalogue number unknown); Fabiani (1910a) reported three specimens from Bocca d'Ansiesa and "Fontanella" di Grancona (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1994) reported one specimen (MCZ 1421) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); De Angeli (1995) reported 18 specimens (MCZ from 1498 to 1514) from "Fontanella" di Grancona (Vicenza); Beschin *et al.* (1998) reported one specimen (MCZ 1521) from "Rossi" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Palaeograpsus sp.

1905 – *Palaeograpsus* sp. *in* Checchia-Rispoli; p. 322
1929 – *Palaeograpsus* sp. *in* Glaessner; p. 296
1933 – *Palaeograpsus* sp. *in* Di Salvo; p. 38

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1905) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown); Di Salvo (1933) reported one specimen from La Pietra Lunga (Palermo) (MGUP, catalogue number unknown).

Panopeus H. Milne Edwards, 1834

Type species: *Panopeus herbstii* H. Milne Edwards, 1834.
Stratigraphic range: Eocene – Recent.

Panopeus bolcensis De Zigno, 1915

***Cancer bolcensis* De Zigno** *in letteris*
1975 – *Panopeus bolcensis* De Zigno *in* Secretan; p. 359, Text-fig. 19, Pl. 22, 23 (figs. 3-4)

Holotype: MNHN 18.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported three specimens (MNHN 18; MGPD 6793-6803, 100-100bis) from Monte Bolca (Verona).

Panopeus granulineatus Müller & Collins, 1991

1933 – *Pilodius mediterraneus* Lörenthey *in* Di Salvo; p. 31, Pl. 2 (fig. 6 a-b)
1991 – *Panopeus granulineatus* Müller & Collins; p. 74, Text-fig. 4 d, Pl. 5 (figs. 3-4, 6)

Holotype: MAFI EGA-11.1 (M.91-167).
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported one specimen (MGUP 2621) from La Pietra Lunga (Palermo).
Note: Di Salvo (1933) included the Sicilian specimen in *Pilumnus mediterraneus* (= *Pilodius mediterraneus*) Lörenthey, 1897, known from the middle Miocene of Hungary. The study of the dorsal surface of the carapace of the Sicilian specimen pointed out shape and characters similar with *Panopeus granulineatus* Müller & Collins, 1991, from the upper Eocene (Priabonian) of Hungary.

Panopeus vicentinus (Bittner, 1875)

1875 – *Panopaeus Vicentinus* Bittner; p. 33, Pl. 2 (fig. 7)
1910a – *Panopaeus vicentinus* Bittner *in* Fabiani; p. 27
1915 – *Panopeus vicetinus* Bittner *in* Fabiani; p. 285
1915 – *Panopaeus vicentinus* Bittner *in* Dainelli, p. 699
1929 – *Panopeus vicentinus* Bittner *in* Glaessner; p. 304
2001 – *Panopeus vicentinus* Bittner *in* De Angeli & Beschin; p. 36
2004 – *Panopeus vicentinus* Bittner *in* Beschin & De Angeli; p. 21

Holotype: unknown.

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto, Friuli-Venezia Giulia.
Material: Bittner (1875) reported this species from Ciupio (Verona) (repository and catalogue number unknown); Dainelli (1915) reported one specimen from Buttrio (Udine) (repository and catalogue number unknown).

Family Pilumnidae Samouelle, 1819

Eohalimede Blow & Manning, 1996

Type species: *Eohalimede talleri* Blow & Manning, 1996.
Stratigraphic range: middle Eocene (Lutetian).

Eohalimede granosa Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Eohalimede granosa* Beschin, Busulini, De Angeli & Tessier; p. 19, Text-fig. 14, Pl. 4 (figs. 1-2)
2004 – *Eohalimede granosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2005 – *Eohalimede granosa* Beschin, Busulini, De Angeli & Tessier *in* Beschin, De Angeli, Checchi & Zarantonello; p. 25, Pl. 5 (fig. 6)

Holotype: MCZ 2279 (I.G. 296407).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported two specimens (MCZ 2279, 2280) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2005) reported one specimen (MCZ 2341) from Grola di Cornedo Vicentino (Vicenza).

Eopilumnus Beschin, Busulini, De Angeli & Tessier, 2002

Type species: *Eopilumnus checchii* Beschin, Busulini, De Angeli & Tessier, 2002.
Stratigraphic range: middle Eocene (Lutetian).

Eopilumnus checchii Beschin, Busulini, De Angeli & Tessier, 2002

2002 – *Eopilumnus checchii* Beschin, Busulini, De Angeli & Tessier; p. 18, Text-fig. 13, Pl. 3 (figs. 4-5)
2004 – *Eopilumnus checchii* Beschin, Busulini, De Angeli & Tessier *in* Beschin & De Angeli; p. 20
2004 – *Eopilumnus checchii* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MCZ 2276 (I.G. 296404).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2002) reported three specimens (MCZ from 2276 to 2278) from "Main" quarry of Arzignano (Vicenza).

Eumorphactaea Bittner, 1875

Type species: *Eumorphactaea scissifrons* Bittner, 1875.
Stratigraphic range: middle Eocene (Lutetian).

Eumorphactaea scissifrons Bittner, 1875

1875 – *Eumorphactaea scissifrons* Bittner; p. 92, Pl. 2 (fig. 12)
1883 – *Eumorphactaea scissifrons* Bittner *in* Bittner; p. 313, Pl. 1 (fig. 10)
1910a – *Eumorphactaea scissifrons* Bittner *in* Fabiani; p. 27
1915 – *Eumorphactaea scissifrons* Bittner *in* Fabiani; p. 285
1929 – *Eumorphactaea scissifrons* Bittner *in* Glaessner; p. 170
1969 – *Eumorphactaea scissifrons* Bittner *in* Glaessner; p. 517
1969 – *Eumorphactaea scissifrons* Bittner *in* Via Boada; p. 376
2001 – *Eumorphactaea scissifrons* Bittner *in* De Angeli & Beschin; p. 36
2005 – *Eumorphactaea scissifrons* Bittner *in* Beschin, De Angeli, Checchi & Zarantonello; p. 24, Text-fig. 16, Pl. 5 (figs. 2-3)

Holotype: MNHB K114, MB.A. 664.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875, 1883) reported one specimen (MNHB K114, MB.A. 664) from Ciupio (Verona); Beschin *et al.* (2005) reported four specimens (MCZ 2354, 2377; MV 45, 05/20) from Grola di Cornedo Vicentino (Vicenza).

Galenopsis A. Milne Edwards, 1865

Type species: *Galenopsis typica* A. Milne Edwards, 1865.
Stratigraphic range: Eocene – Pliocene.

Galenopsis crassifrons A. Milne Edwards, 1865

1865 – *Galenopsis crassifrons* A. Milne Edwards; p. 347, Pl. 30 (fig. 2)
1901 – *Galenopsis crassifrons* A. Milne Edwards *in* Oppenheim; p. 284
1908 – *Galenopsis crassifrons* A. Milne Edwards *in* Fabiani; p. 211, 236
1910a – *Galenopsis crassifrons* A. Milne Edwards *in* Fabiani; p. 27
1915 – *Galenopsis crassifrons* A. Milne Edwards *in* Fabiani; p. 285
1929 – *Galenopsis crassifrons* A. Milne Edwards *in* Glaessner; p. 177
2001 – *Galenopsis crassifrons* A. Milne Edwards *in* De Angeli & Beschin; p. 37
2004 – *Galenopsis crassifrons* A. Milne Edwards *in* Beschin & De Angeli; p. 21

Holotype: MNHN R03798.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: A. Milne Edwards (1862-1865) reported one specimen (MNHN R03798) from Lonigo (Vicenza).

Galenopsis cfr. *G. murchisoni* A. Milne Edwards, 1865

1905 – *Galenopsis* cfr. *G. murchisoni* A. Milne Edwards *in* Checchia-Rispoli; p. 318
1929 – *Galenopsis* cfr. *G. murchisoni* A. Milne Edwards *in* Glaessner; p. 178
1933 – *Galenopsis* cfr. *G. murchisoni* A. Milne Edwards *in* Di Salvo; p. 34

Stratigraphic range: middle/upper Eocene.
Occurrence: Sicilia.

Material: Checchia-Rispoli (1905) reported one specimen (MGUP 2607) from Balzo del Gatto (Palermo); Di Salvo (1933) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown).

Galenopsis ristorii Checchia-Rispoli, 1907

1907 – *Galenopsis ristorii* Checchia-Rispoli; p. 26, Pl. 1 (figs. 1-2)
1929 – *Galenopsis ristorii* Checchia-Rispoli *in* Glaessner; p. 178
1933 – *Galenopsis ristorii* Checchia-Rispoli *in* Di Salvo; p. 37

Holotype: MGUP.
Stratigraphic range: middle/upper Eocene.
Occurrence: Sicilia.
Material: Checchia-Rispoli (1907) reported one specimen from Bagheria (Palermo) (MGUP, catalogue number unknown); Di Salvo (1933) reported one specimen from Bichinello (Palermo) (MGUP, catalogue number unknown).

Galenopsis schopeni Checchia-Rispoli, 1905

1905 – *Galenopsis schopeni* Checchia-Rispoli; p. 320, Pl. 1 (figs. 3-4)
1929 – *Galenopsis schopeni* Checchia-Rispoli *in* Glaessner; p. 179
1933 – *Galenopsis schopeni* Checchia-Rispoli *in* Di Salvo; p. 36

Holotype: MGUP.
Stratigraphic range: middle/upper Eocene.
Occurrence: Sicilia.
Material: Checchia-Rispoli (1905) and Di Salvo (1933) reported four specimens (MGUP 2606, 2608, 2609, 2610) from Balzo del Gatto (Palermo).

Galenopsis similis Bittner, 1875

1875 – *Galenopsis similis* Bittner; p. 97, Pl. 2 (fig. 9)
1898 – *Galenopsis similis* Bittner *in* Lörenthey; p. 64, Pl. 5 (figs. 1-2)
1899 – *Galenopsis similis* Bittner *in* Oppenheim; p. 58
1905 – *Galenopsis similis* Bittner *in* Checchia-Rispoli; p. 319
1910a – *Galenopsis similis* Bittner *in* Fabiani; p. 27
1915 – *Galenopsis similis* Bittner *in* Fabiani; p. 285
1929 – *Galenopsis similis* Bittner *in* Glaessner; p. 179
1929 – *Galenopsis similis* Bittner *in* Lörenthey & Beurlen; p. 247, Pl. 16 (figs. 3-4, 6)
1933 – *Galenopsis similis* Bittner *in* Di Salvo; p. 34
1969 – *Galenopsis similis* Bittner *in* Via Boada; p. 378
1975 – *Galenopsis similis* Bittner *in* Müller; p. 510, 516
1991 – *Galenopsis similis* Bittner *in* Müller & Collins; p. 86, Pl. 8 (figs. 4-5)
2000 – *Galenopsis similis* Bittner *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 1 (fig. 5)
2001 – *Galenopsis similis* Bittner *in* De Angeli & Beschin; p. 37
2004 – *Galenopsis similis* Bittner *in* Beschin & De Angeli; p. 21

Holotype: unknown.
Stratigraphic range: middle/upper Eocene – lower Oligocene.
Occurrence: Veneto, Sicilia.
Material: Bittner (1875) reported this species from Monte di Malo and Muzzolon (Vicenza) (catalogue number unknown); Checchia-Rispoli (1905) and Di Salvo (1933) reported two specimens (MGUP 2603, 2605) from Balzo del Gatto and Bichinello (Palermo); Beschin *et al.* (2000) reported one specimen (MCZ 1742) from "Gecchelina" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Galenopsis sp.

1883 – *Galenopsis* sp. *in* Bittner; p. 314
1929 – *Galenopsis* sp. *in* Glaessner; p. 179

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1883) reported one specimen from Monte Magrè di Schio (Vicenza) (repository and catalogue number unknown).

Galenopsis sp.

1886 – *Galenopsis* sp. *in* Ristori; p. 103, Pl. 2 (fig. 7)
1929 – *Galenopsis* sp. *in* Glaessner; p. 179

Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1886) reported one specimen from Orciano (Pisa), today lost.

Galenopsis sp.

1933 – *Galenopsis* sp. *in* Di Salvo; p. 37, Pl. 2 (fig. 8)

Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported one specimen (MGUP 2599) from Bichinello (Palermo).

Lobogalenopsis Müller & Collins, 1991

Type species: *Galenopsis quadrilobata* Lörenthey, 1897.
Stratigraphic range: upper Eocene (Priabonian).

Lobogalenopsis quadrilobata (Lörenthey, 1897)

1897 – *Galenopsis quadrilobata* Lörenthey; p. 156
1898a – *Galenopsis quadrilobata* Lörenthey *in* Lörenthey; p. 100
1898b – *Galenopsis quadrilobata* Lörenthey *in* Lörenthey; p. 87, Pl. 5 (fig. 3)
1898c – *Galenopsis quadrilobata* Lörenthey *in* Lörenthey; p. 60, Pl. 5 (fig. 3)
1929 – *Galenopsis quadrilobata* Lörenthey *in* Glaessner; p. 178
1929 – *Galenopsis quadrilobata* Lörenthey *in* Lörenthey & Beurlen; p. 249, Pl. 16 (fig. 5)
1933 – *Galenopsis quadrilobata* Lörenthey *in* Di Salvo; p. 35, Pl. 3 (fig. 3 a-c)
1969 – *Galenopsis quadrilobata* Lörenthey *in* Via Boada; p. 378
1991 – *Lobogalenopsis quadrilobata* (Lörenthey) *in* Müller & Collins; p. 88, Text-fig. 5 f, Pl. 8 (figs. 8-10)

Holotype: MAFI.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported two specimens (MGUP 323, 2593) from Balzo del Gatto (Palermo).

Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Lobonotus A. Milne Edwards, 1864

Type species: *Lobonotus sculptus* A. Milne Edwards, 1864.
Stratigraphic range: Eocene – Miocene.

Lobonotus cfr. *L. orientalis* Collins & Morris, 1978

1983 – *Lobonotus* cfr. *orientalis* Collins & Morris *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 65, Pl. 3 (fig. 4)
2001 – *Lobonotus* cfr. *orientalis* Collins & Morris *in* De Angeli & Beschin, p. 36
2004 – *Lobonotus* cfr. *orientalis* Collins & Morris *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1983) reported four specimens (*31, *35, *77; MSNVE 10095) from "Main" quarry of Arzignano (Vicenza).
Note: *Lobonotus orientalis* Collins & Morris, 1978, from the Eocene of Pakistan was recently ascribed to the new genus *Pakicarcinus* Schweitzer, Feldmann & Gingerich, 2004. The Italian species must be probably considered a new species of *Lobonotus*.

Pilumnus Leach, 1815

Type species: *Cancer hirtellus* Linnaeus, 1761.
Stratigraphic range: Oligocene – Recent.

Pilumnus villosissimus (Rafinesque-Schmaltz, 1814)

1814 – *Cancer villosissimus* Rafinesque-Schmaltz; p. 20
1827 – *Pilumnus villosus* Risso; p. 10
1885 – *Pilumnus villosus* Risso *in* Carus; p. 514
1914 – *Pilumnus villosus* Risso *in* M. Gemmellaro; p. 86, Pl. 1 (figs. 19-20)
1918 – *Pilumnus hirtellus* var. *villosus* Risso *in* Pesta; p. 417, Text-fig. 137
1929 – *Pilumnus hirtellus* var. *villosa* Risso *in* Glaessner; p. 316
1940 – *Pilumnus villosus* Risso *in* Bouvier; p. 256
1956 – *Pilumnus villosus* Risso *in* Monod; p. 249
1958 – *Pilumnus villosus* Risso *in* Holthuis & Gottlieb; p. 97
1965 – *Pilumnus villosus* Risso *in* Forest; p. 378
1969 – *Pilumnus villosissimus* (Rafinesque-Schmaltz) *in* Zariquiey Alvarez; p. 392

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: M. Gemmellaro (1914) reported some specimens from Ficarazzi (Palermo), housed in Marchese di Monterosato's collection (MGUP, catalogue number unknown).

Pilumnus sp.

1981 – *Pilumnus* sp. *in* Varola; p. 29, Pl. 7 (fig. 3)

Stratigraphic range: Pliocene.
Occurrence. Puglia.
Material: Varola (1981) reported one specimen from Leuca (Lecce) (GNSL, catalogue number unknown).

Pilumnus sp.

2004 – *Pilumnus* sp. *in* Garassino, De Angeli, Gallo & Pasini; p. 273, Text-fig. 13

Stratigraphic range: Pliocene.
Occurrence: Piemonte.
Material: Garassino *et al.* (2004) reported two specimens (PU 41183, 41184) from Cossato (Biella).

Titanocarcinus A. Milne Edwards, 1863

Type species: *Titanocarcinus serratifrons* A. Milne Edwards, 1863.
Stratigraphic range: Upper Cretaceous (Senonian) – Pliocene.

Titanocarcinus aculeatus Busulini, Tessier & Visentin, 1984

1982 – *Titanocarcinus* aff. *raulinianus in* Busulini, Tessier & Visentin; p. 82, Text-fig. 3
1984 – *Titanocarcinus aculeatus* Busulini, Tessier & Visentin; p. 110, Pl. 1 (figs. 1-3), Pl. 2 (figs. 1-2), Pl. 3 (figs. 1- 2)
2001 – *Titanocarcinus aculeatus* Busulini, Tessier & Visentin *in* De Angeli & Beschin; p. 35
2002 – *Titanocarcinus aculeatus* Busulini, Tessier & Visentin *in* Beschin, Busulini, De Angeli & Tessier; p. 20, Text-fig. 15, Pl. 4 (fig. 3)
2004 – *Titanocarcinus aculeatus* Busulini, Tessier & Visentin *in* Beschin & De Angeli; p. 21
2004 – *Titanocarcinus aculeatus* Busulini, Tessier & Visentin *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MSNVE 10441.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1984) reported 20 specimens (from *60 to *70, *150, *178, from *184 to *187; MSNVE 10441, 10442, 10443) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (2002) reported two specimens (MCZ 1188, 1201) from "Main" quarry of Arzignano (Vicenza).

Titanocarcinus edwardsi (E. Sismonda, 1846)

1846 – *Xantho edwardsi* E. Sismonda; p. 61, Pl. 3 (fig. 5)
1863 – *Titanocarcinus edwardsi* (E. Sismonda) *in* A. Milne Edwards; p. 35
1864 – *Titanocarcinus edwardsi* (E. Sismonda) *in* A. Milne Edwards; Pl. 10 (fig. 3)
1886 – *Titanocarcinus edwardsi* (E. Sismonda) *in* Ristori; p. 99, Pl. 2 (fig. 9)
1895 – *Titanocarcinus edwardsi* (E. Sismonda) *in* Crema; p. 678, Text-figs. 17-18
1923 – *Titanocarcinus edwardsi* (E. Sismonda) *in* Tettoni; p. 162
1929 – *Titanocarcinus edwardsi* (E. Sismonda) *in* Glaessner; p. 384

Holotype: lost.
Stratigraphic range: upper Pliocene (Piacentian).
Occurrence: Piemonte, Toscana.

Material: E. Sismonda (1846) reported two specimens from Torino and Asti, today lost; Ristori (1886) reported two specimens from Asti and Orciano (Pisa), today lost; Crema (1895) reported three specimens from Bra (Cuneo), today lost; Tettoni (1923) reported one specimen from S. Venanzio (Modena) (MGUM, catalogue number unknown).

Titanocarcinus euglyphos Bittner, 1875

1875 – *Titanocarcinus euglyphos* Bittner; p. 95, Pl. 2 (fig. 6)
1910a – *Titanocarcinus euglyphos* Bittner *in* Fabiani; p. 26
1915 – *Titanocarcinus euglyphos* Bittner *in* Fabiani; p. 285
1929 – *Titanocarcinus euglyphos* Bittner *in* Glaessner; p. 385
1983 – *Titanocarcinus euglyphos* Bittner *in* Busulini, Tessier, Visentin, Beschin, De Angeli & Rossi; p. 66, Pl. 3 (fig. 1)
1994 – *Titanocarcinus euglyphos* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 189, Pl. 9 (fig. 2)
2001 – *Titanocarcinus euglyphos* Bittner *in* De Angeli & Beschin; p. 35, Text-fig. 31
2004 – *Titanocarcinus euglyphos* Bittner *in* Beschin & De Angeli; p. 21
2004 – *Titanocarcinus euglyphos* Bittner *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: unknown.
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875) reported this species from Ciupio (Verona) (repository and catalogue number unknown); Busulini *et al.* (1983) reported seven specimens (*6, *9, *21, *22, *76; MSNVE 10097, 10098) from "Main" quarry of Arzignano (Vicenza); Beschin *et al.* (1994) reported three specimens (MCZ 1223, 1306, 1457) from "Boschetto" quarry of Nogarole Vicentino (Vicenza).
Note: Feldmann *et al.* (1998) described this species from the middle Eocene (Lutetian) of N Carolina (United States). The American specimen show the following differences respect the Italian ones: wider carapace, more coverging posterolateral margins and wider cardiac region. Therefore, the American species could be ascribed to a different species.

Titanocarcinus kochii Lörenthey, 1897

1897 – *Titanocarcinus kochii* Lörenthey; p. 155
1929 – *Titanocarcinus kochii* Lörenthey *in* Lörenthey & Beurlen; p. 239, Pl. 11 (figs. 4-5)
1929 – *Titanocarcinus kochi* Lörenthey *in* Glaessner; p. 385
1933 – *Titanocarcinus kochii* Lörenthey *in* Di Salvo; p. 28, Pl. 1 (fig. 2 a-b)
1969 – *Titanocarcinus kochii* Lörenthey *in* Via Boada; p. 420
1991 – *Titanocarcinus kochii* Lörenthey *in* Müller & Collins; p. 81, Pl. 6 (figs 2, 5-6)

Holotype: MAFI.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported two specimens (MGUP 2613, 2618) from La Pietra Lunga and San Cipirrello (Palermo).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Titanocarcinus raulinianus A. Milne Edwards, 1863

1863 – *Titanocarcinus raulinianus* A. Milne Edwards; p. 37
1864 – *Titanocarcinus raulinianus* A. Milne Edwards *in* A. Milne Edwards; Pl. 9 (figs. 3-4)
1893 – *Titanocarcinus raulinianus* A. Milne Edwards *in* Ristori; p. 212
1898 – *Titanocarcinus raulinianus* A. Milne Edwards *in* Lörenthey; p. 57
1903 – *Titanocarcinus raulinianus* A. Milne Edwards *in* Lörenthey; p. 113, Pl. 2 (fig. 1)
1929 – *Titanocarcinus raulinianus* A. Milne Edwards *in* Glaessner; p. 385
2000 – *Titanocarcinus raulinianus* A. Milne Edwards *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 2 (fig. 3)
2001 – *Titanocarcinus raulinianus* A. Milne Edwards *in* De Angeli & Beschin; p. 36
2004 – *Titanocarcinus raulinianus* A. Milne Edwards *in* Beschin & De Angeli; p. 21
2006a – *Titanocarcinus raulinianus* A. Milne Edwards *in* De Angeli & Garassino; p. 287, Text-fig. 11

Holotype: unknown.
Stratigraphic range: Eocene.
Occurrence: Veneto, Friuli-Venezia Giulia, Puglia.
Material: Ristori (1893) reported one specimen from Monte Saraceno (Gargano) (repository and catalogue number unknown); Beschin *et al.* (2000) reported one specimen (MCZ 1819) from "Gecchelina" quarry of Monte di Malo (Vicenza); De Angeli & Garassino (2006a) reported one specimen (MFSN 29051) from Casali Ottelio (Udine).
Note: this species is also reported from the middle/upper Eocene of France and Hungary.

Titanocarcinus subovalis Ristori, 1896

1896 – *Titanocarcinus subovalis* Ristori; p. 504, Pl. 12 (figs. 3-4)
1929 – *Titanocarcinus subovalis* Ristori *in* Glaessner; p. 386
1981 – *Titanocarcinus subovalis* Ristori *in* Delle Cave; p. 47

Holotype: IGF 620E (figured by Ristori in Pl. 2, figs. 3-4).
Stratigraphic range: Pliocene.
Occurrence: Toscana.
Material: Ristori (1896) reported one specimen (IGF 620E) from Arbia (Siena).

Titanocarcinus sp.

1933 – *Titanocarcinus* sp. *in* Di Salvo; p. 30, Pl. 2 (fig. 9)

Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported two specimens (MGUP 2617, 2619) from Ponte di Castronuovo and Balzo del Gatto (Palermo).

Family Xanthidae MacLeay, 1838

Monodaeus Guinot, 1967

Type species: *Xantho couchi* Bell *in* Couch, 1851 (= *Xantho tuberculata* Bell, 1852).

Stratigraphic range: Pliocene – Recent.

Monodaeus bortolottii Delle Cave, 1988

1988b – *Monodaeus bortolottii* Delle Cave; p. 123, Pl. 1 (figs. 1-2), Pl. 2 (figs. 1-5)
1993 – *Monodaeus* cfr. *M. bortolottii* Delle Cave *in* Müller; p. 21, Text-fig. 10 F

Holotype: IGF 1786E.
Stratigraphic range: upper Pliocene (Piacentian).
Occurrence: Toscana.
Material: Delle Cave (1988b) reported one specimen (IGF 1786E) from Botro dell'Alpino (Volterra).
Note: this species is also reported from the Neogene of Spain.

Paraxanthosia Müller & Collins, 1991

Type species: *Paraxanthosia budensis* Müller & Collins, 1991.
Stratigraphic range: middle/upper Eocene.

Paraxanthosia tuberculata Beschin, De Angeli, Checchi & Zarantonello, 2005

2005 – *Paraxanthosia tuberculata* Beschin, De Angeli, Checchi & Zarantonello; p. 23, Text-fig. 15, Pl. 4 (fig. 8)

Holotype: MCZ 2333 (I.G. 296552).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported one specimen (MCZ 2333) from Grola di Cornedo Vicentino (Vicenza).

Phlyctenodes A. Milne Edwards, 1862

Type species: *Phlyctenodes tuberculosus* A. Milne Edwards, 1862.
Stratigraphic range: Eocene – ?Miocene.

Phlyctenodes dalpiazi Fabiani, 1911

1910a – *Phlyctenodes* aff. *Phl. Krenneri in* Fabiani; p. 25
1911 – *Phlyctenodes Dalpiazi* Fabiani; p. 42, Text-fig. 1 a-b
1915 – *Phlyctenodes Dalpiazi* Fabiani *in* Fabiani; p. 285
1929 – *Phlyctenodes dalpiazi* Fabiani *in* Glaessner; p. 313
2001 – *Phlyctenodes dalpiazi* Fabiani *in* Beschin, De Angeli & Checchi; p. 29
2001 – *Phlyctenodes dalpiazi* Fabiani *in* De Angeli & Beschin; p. 34
2002 – *Phlyctenodes dalpiazi* Fabiani *in* De Angeli & Garassino; p. 5

Holotype: MGPD 23654.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Veneto.
Material: Fabiani (1910a, 1911) reported one specimen (MGPD 23654) from Tongriani limestones (Oligocene) of S. Feliciano (Vicenza).
Note: a recent study on the limestones including a decapod fauna of S. Feliciano allowed to date these levels to the upper Eocene (Priabonian) (De Angeli & Garassino, 2002).

?*Phlyctenodes hantkeni* Lörenthey, 1898

1898 – *Phlyctenodes Hantkeni* Lörenthey; p. 44, Pl. 2 (fig. 10)
1929 – *Phlyctenodes Hantkeni* Lörenthey *in* Lörenthey & Beurlen; p. 199, Pl. 12 (fig. 8)
1929 – *Phlyctenodes Hantkeni* Lörenthey *in* Glaessner; p. 313
1933 – *Phlyctenodes hantkeni* Lörenthey *in* Di Salvo; p. 21, Pl. 2 (fig. 1 a-d)
1991 – ?*Phlyctenodes hantkeni* Lörenthey *in* Müller & Collins; p. 49

Holotype: MAFI.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported 13 specimens (MGUP 321, 423, 2587, 2588, 2589, 2590, 2591, 2595, 2600, 2601) from Balzo del Gatto, La Pietra Lunga, San Cipriello (Palermo).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

?*Phlyctenodes irregularis* Ristori, 1896

1896 – *Phlyctenodes irregularis* Ristori; p. 506, Pl. 12 (fig. 1)
1929 – *Phlyctenodes irregularis* Ristori *in* Glaessner; p. 313

Holotype: unknown.
Stratigraphic range: middle Miocene.
Occurrence: Piemonte.
Material: Ristori (1896) reported one specimen from Serravalle (repository and catalogue number unknown).
Note: Ristori (1896) described this species on the morphological characters of one incomplete carapace poorly preserved, ascribing it to *Phlyctenodes* A. Milne Edwards, 1862, for the presence of strong irregular tubercles on the dorsal surface of carapace. However *Phlyctenodes* is a typically genus from the Eocene and the ornamentation with strong irregular tubercles of Ristori's species resembles that of *Daira speciosa* (Reuss, 1871) discovered invariably in reefal structures in the Paratetheys and in the Mediterranean Miocene.

Phlyctenodes krenneri Lörenthey, 1897

1897 – *Phlyctenodes Krenneri* Lörenthey; p. 154
1898 – *Phlyctenodes Krenneri* Lörenthey; p. 46, Pl. 2 (fig. 10)
1905 – *Phlyctenodes Krenneri* Lörenthey *in* Checchia-Rispoli; p. 312, Pl. 1 (fig. 10)
1911 – *Phlyctenodes Krenneri* Lörenthey *in* Fabiani; p. 44, Text-fig. 2
1929 – *Phlyctenodes Krenneri* Lörenthey *in* Glaessner; p. 313
1933 – *Phlyctenodes krenneri* Lörenthey *in* Di Salvo; p. 20
1969 – *Phlyctenodes krenneri* Lörenthey *in* Via Boada; p. 408
1975 – *Phlyctenodes krenneri* Lörenthey *in* Müller; p. 516, 520
1991 – *Phlyctenodes krenneri* Lörenthey *in* Müller & Collins; p. 76, Pl. 5 (fig. 9), Pl. 6 (fig. 1)

Holotype: MAFI.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1905) reported one specimen from Balzo del Gatto (Palermo) (MGUP, catalogue number unknown); Di Salvo (1933) reported

six specimens (MGUP 2602, 2623, 2596, 2597, 2598) from Bichinello, La Pietra Lunga, and Balzo del Gatto (Palermo).

Note: this species is also reported fron the upper Eocene (Priabonian) of Hungary.

Phlyctenodes nicolisi Bittner, 1884

1884 – *Phlyctenodes Nicolisi* Bittner; p. 17, Pl. 1 (fig. 5)
1915 – *Phlyctenodes Nicolisi* Bittner *in* Fabiani; p. 284
1929 – *Phlyctenodes Nicolisi* Bittner *in* Glaessner; p. 313
2000 – *Phlyctenodes nicolisi* Bittner *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 2 (fig. 2 a-b)
2001 – *Phlyctenodes nicolisi* Bittner *in* De Angeli & Beschin, p. 34

Holotype: MSNV 1892.
Stratigraphic range: lower/ middle Eocene (Ypresian – Lutetian).
Occurrence: Veneto.
Material: Bittner (1884) reported one specimen (MSNV 1892) from "Scole" quarry of Avesa (Verona); Beschin *et al.* (2000) reported one specimen (MCZ 1830) from "Gecchelina" quarry of Monte di Malo (Vicenza).

Phlyctenodes steinmanni Lörenthey, 1901

1901 – *Phlyctenodes Steinmanni* Lörenthey; p. 815, Pl. 1 (fig. 4)
1901 – *Phlyctenodes Steinmanni* Lörenthey; p. 111, Pl. 1 (fig. 4)
1929 – *Phlyctenodes Steinmanni* Lörenthey *in* Glaessner; p. 314
1929 – *Phlyctenodes Steinmanni* Lörenthey *in* Lörenthey & Beurlen; p. 200, Pl. 12 (fig. 2)
1991 – *Phlyctenodes steinmanni* Lörenthey *in* Müller & Collins; p. 76, Pl. 5 (fig. 13)
1994 – *Phlyctenodes steinmanni* Lörenthey *in* Beschin, Busulini, De Angeli & Tessier; p. 188, Pl. 9 (fig. 3)
2000 – *Phlyctenodes* cf. *steinmanni* Lörenthey *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 8, Pl. 2 (fig. 4)
2001 – *Phlyctenodes steinmanni* Lörenthey *in* De Angeli & Beschin; p. 35

Holotype: MAFI.
Stratigraphic range: middle/upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Beschin *et al.* (1994) reported two specimens (MCZ 1214, 1215) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (2000) reported one specimen (MCZ 1784) from "Gecchelina" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Phlyctenodes sp.

1982 – *Phlyctenodes* sp. *in* Busulini, Tessier & Visentin; p. 82
2004 – *Phlyctenodes* sp. *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Busulini *et al.* (1982) reported one specimen from "Main" quarry of Arzignano (Vicenza) (SV, catalogue number unknown).

Xantho Leach, 1804

Type species: *Xantho floridus* Montagu, 1813.
Stratigraphic range: Miocene – Recent.

Xantho floridus Montagu, 1813

1813 – *Xantho floridus* Montagu; p. 85, Pl. 2 (fig. 1)
1815 – *Cancer incisus* Leach; p. 320, Pl. 11 (figs. 1-6)
1815 – *Xantho floridus* Montagu *in* Leach; p. 320
1830 – *Cancer floridus* (Montagu) *in* Desmarest & Bosc; p. 205
1834 – *Xantho floridus* Montagu *in* A. Milne Edwards; p. 324
1850 – *Cancer poressa* Olivi *in* Costa; p. 8, Pl. 1 (fig. 2)
1885 – *Xantho floridus* Montagu *in* Carus; p. 512, 513
1899 – *Xantho floridus* Montagu *in* Acloque; p. 142
1903 – *Xantho floridus* Montagu *in* Checchia-Rispoli; p. 488, Text-fig. without number
1914 – *Xantho floridus* Montagu *in* M. Gemmellaro; p. 58, Pl. 1 (fig. 18)
1921 – *Xantho floridus* Montagu *in* Bell; p. 9
1929 – *Xantho floridus* Montagu *in* Glaessner; p. 394

Holotype: unknown.
Stratigraphic range: upper Pleistocene (Sicilian).
Occurrence: Sicilia.
Material: Checchia-Rispoli (1903) reported one specimen from Palermo, housed in Di-Stefano's collection (repository and catalogue number unknown); M. Gemmellaro (1914) reported some specimens from Ficarazzi (Palermo), housed in Marchese di Monterosato's collection (MGUP, catalogue number unknown).

?*Xantho lovisatoi* (Lörenthey, 1907)

1907 – *Xanthus lovisatoi* Lörenthey; p. 91, Pl. 3 (fig. 12)
1909 – ?*Xanthus lovisatoi* Lörenthey *in* Lörenthey; p. 245, Pl. 1 (fig. 12 a-d)
1929 – ?*Xantho lovisatoi* (Lörenthey) *in* Glaessner; p. 395

Holotype: unknown.
Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Lörenthey (1909) reported some specimens from Capo S. Elia (Cagliari), housed in Lovisato's collection (repository and catalogue number unknown).

Xantho moldavicus (Yanakevich, 1977)

1928 – *Titanocarcinus vulgaris* Glaessner; p. 185, Pl. 3 (figs. 9-11)
1929 – *Titanocarcinus vulgaris* Glaessner *in* Glaessner; p. 386
1953b – *Titanocarcinus vulgaris* Glaessner *in* Bachmayer; p. 254, Pl. 4 (figs. 1-9), Pl. 6 (figs. 1-2)
1974 – *Xantho* cfr. *X. incisus* Leach *in* Müller; p. 123, Pl. 3 (figs. 1-2)
1976 – *Xantho incisus* Leach *in* Müller; p. 152
1977 – *Medaeus moldavicus* Yanakevich; p. 80, Pl. 10 (fig. 4)
1979 – *Xantho* cfr. *X. incisus* Leach *in* Müller; p. 274, Pl. 20 (figs. 1-5)
1979 – *Xantho* cfr. *X. vulgaris* (Glaessner) *in* Förster; p. 100, Text-figs. 14-15, Pl. 3 (figs. 1-3), Pl. 4 (figs. 1-4)
1984 – *Xantho moldavicus* (Yanakevich) *in* Müller; p. 92, Text-figs. 5-8, Pl. 86 (figs. 1-5), Pl. 87 (fig. 1)
1987 – *Xantho* cf. *moldavicus* (Yanakevich) *in* Friebe; p. 61, Pl. 2 (fig. 5)
1991 – *Xantho moldavicus* (Yanakevich) *in* Marras & Ventura; p. 110

1996 – *Xantho moldavicus* (Yanakevich) *in* Müller; p. 11, Pl. 2 (fig. 6)
1998 – *Xantho moldavicus* (Yanakevich) *in* Müller; p. 34
2006 – *Xantho moldavicus* (Yanakevich) *in* Radwański, Górka & Wysocka; p. 96, Pl. 2 (figs. 5, 6)

Holotype: MHMW 1927/I/3.
Stratigraphic range: Miocene.
Occurrence: Sardegna.
Material: Marras & Ventura (1991) reported one specimen from Sassari (repository and catalogue number unknown).
Note: this species is also reported from the lower to the upper Miocene of Austria, Hungary, Poland, Moldavia, and Spain.

Xantho sp.

2001 – *Xantho* sp. *in* Beschin, De Angeli & Checchi; p. 26, Pl. 3 (fig. 4)
2001 – *Xantho* sp. *in* De Angeli & Beschin; p. 35

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported one specimen (MCZ 2119) from Castelgomberto (Vicenza).

†Family Zanthopsidae Via Boada, 1959

Harpactocarcinus A. Milne Edwards, 1862

Type species: *Cancer punctulatus* Desmarest, 1822.
Stratigraphic range: Eocene.

Harpactocarcinus macrodactylus (H. Milne Edwards, 1850)

1850 – *Cancer macrodactylus* H. Milne Edwards *in* D'Archiac; p. 304
1862 – *Harpactocarcinus macrodactylus* (H. Milne Edwards) *in* A. Milne Edwards; p. 70, Pl. 10 (figs. 1, 1 a)
1875 – *Harpactocarcinus macrodactylus* (H. Milne Edwards) *in* Bittner; p. 87
1929 – *Harpactocarcinus punctulatus* (Desmarest) *in* Glaessner; p. 204
1969 – *Harpactocarcinus punctulatus* (Desmarest) *in* Via Boada; p. 381
2000 – *Harpactocarcinus macrodactylus* (H. Milne Edwards) *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Harpactocarcinus macrodactylus* (H. Milne Edwards) *in* De Angeli & Beschin, p. 33, Text-fig. 29
2003 – *Harpactocarcinus punctulatus* (Desmarest) *in* Schweitzer; p. 1118

Holotype: MNHN R03825.
Stratigraphic range: lower Eocene (Ypresian).
Occurrence: Veneto.
Material: H. Milne Edwards (1850) and A. Milne Edwards (1862-1865) reported one specimen (MNHN R03825) from San Floriano (Verona).
Note: this species was described by H. Milne Edwards (1850), and figured later by A. Milne Edwards (1862) on only one male specimen with a cheliped strongly developed from the lower Eocene of S. Floriano (Verona). Glaessner (1929, p. 204), Via Boada (1969, p. 253), and Schweitzer (2003, p. 1118) suggested this species as synonym with *H. punctulatus* (Desmarest, 1822). However, *H. macrodactylus* differs from *H. punctulatus* because the narrower frontal lobes and the different ratio between the fronto-orbital margin and the maximum wide of the carapace. The strong development of the cheliped and the evident convexity of the lower margin of the fixed finger, considered as probable anomaly of the type specimen, is instead a typical morphological character of this species. *Harpactocarcinus macrodactylus*, from the lower/middle Eocene of Monte Baldo and Lessini Veronesi, is sometimes housed in some Museums of Veneto with the name *H. punctulatus*. Three specimens (MCZ 1319, 1320, 1357) of this species come from Ferrara del Baldo (Verona).

Harpactocarcinus ovalis A. Milne Edwards, 1862

1862 – *Harpactocarcinus ovalis* A. Milne Edwards; p.72, Pl. 9 (fig. 2)
1875 – *Harpactocarcinus ovalis* A. Milne Edwards *in* Bittner; p. 88
1910a – *Harpactocarcinus ovalis* A. Milne Edwards *in* Fabiani; p. 26
1915 – *Harpactocarcinus ovalis* A. Milne Edwards *in* Fabiani; p. 284
1927 – *Harpactocarcinus ovalis* A. Milne Edwards *in* Van Straelen; p. 89
1929 – *Harpactocarcinus ovalis* A. Milne Edwards *in* Glaessner; p. 203
2003 – *Harpactocarcinus ovalis* A. Milne Edwards *in* Schweitzer; p. 1118

Holotype: MNHN R03816 (syntype, cast).
Stratigraphic range: Eocene.
Occurrence: Veneto.
Material: Bittner (1875) reported this species from Vicentino (locality, repository and catalogue number unknown).
Note: this species is also reported from the Eocene of Spain.

Harpactocarcinus punctulatus (Desmarest, 1822)

1820 – *Brachyurites australis in* Schlotheim; p. 36 (*nom. nud.*)
1822 – *Cancer punctulatus* Desmarest; p. 92, Pl. 7 (figs. 3-4)
1846 – *Cancer punctulatus* Desmarest *in* d'Archiac; p. 216
1850 – *Cancer punctulatus* Desmarest *in* H. Milne Edwards; p. 304
1852 – *Cancer punctulatus* Desmarest *in* v. Meyer; p. 302
1854 – *Cancer punctulatus* Desmarest *in* Catullo; p. 886
1859 – *Cancer punctulatus* Desmarest *in* Reuss; p. 25, Pl. 15 (figs. 1-5), Pl. 16 (figs. 1-4), Pl. 17 (figs. 1-4)
1859 – *Cancer brachychelus* Reuss; p. 29, Pl. 13 (fig. 5), Pl. 18 (figs. 1-3)
1861 – Cancer *punctulatus* Desmarest *in* Michelotti; p. 139
1862 – *Harpactocarcinus punctulatus* (Desmarest) *in* A. Milne Edwards; p. 66, Pl. 8 (fig. 1), Pl. 9 (fig. 1)
1875 – *Harpactocarcinus punctulatus* (Desmarest) *in* Bittner; p. 86
1883 – *Harpactocarcinus punctulatus* (Desmarest) *in* Bittner; p. 311
1895 – *Cancer* (*Harpactocarcinus*) *punctulatus* (Desmarest) *in* De Gregorio; p. 10, Pl. 1 (figs. 1-4), Pl. 2 (figs. 1-2, 4-6)
1898 – *Harpactocarcinus punctulatus* (Desmarest) *in* Lörenthey; p. 13, 78, Pl. 7 (fig. 1)
1901 – *Harpactocarcinus punctulatus* (Desmarest) *in* Oppenheim; p. 280

1904 – *Harpactocarcinus punctulatus* (Desmarest) *in* Checchia-Rispoli; p. 50, Text-figs. 1-3
1908 – *Harpactocarcinus punctulatus* (Desmarest) *in* Fabiani; p. 210, 236
1909 – *Harpactocarcinus punctulatus* (Desmarest) *in* Toniolo; p. 292, Pl. 26 (fig. 3)
1910a – *Harpactocarcinus punctulatus* (Desmarest) *in* Fabiani; p. 25
1915 – *Harpactocarcinus punctulatus* (Desmarest) *in* Fabiani; p. 284, 285
1926 – *Harpactocarcinus punctulatus* (Desmarest) *in* Lörenthey; p. 19
1927 – *Harpactocarcinus punctulatus* (Desmarest) *in* Van Straelen; p. 88
1929 – *Harpactocarcinus punctulatus* (Desmarest) *in* Glaessner; p. 204
1929 – *Harpactocarcinus punctulatus* (Desmarest) *in* Lörenthey & Beurlen; p. 206, Pl. 11 (fig. 1)
1936 – *Harpactocarcinus punctulatus* (Desmarest) *in* Van Straelen; p. 5
1941 – *Harpactocarcinus punctulatus* (Desmarest) *in* Via Boada; p. 39, Pls. 4, 8, 9, 11
1952 – *Harpactocarcinus punctulatus* (Desmarest) *in* Via Boada; p. 80
1953 – *Harpactocarcinus punctulatus* (Desmarest) *in* Roger; p. 356, Pl. 10 (fig. 12)
1959 – *Harpactocarcinus punctulatus* (Desmarest) *in* Via Boada; p. 381
1962 – *Harpactocarcinus punctulatus* (Desmarest) *in* Piccoli & Mocellin; p. 65
1969 – *Harpactocarcinus punctulatus* (Desmarest) *in* Via Boada; p. 239, Text-fig. 29, Pls. 24-27
2000 – *Harpactocarcinus punctulatus* (Desmarest) *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Harpactocarcinus punctulatus* (Desmarest) *in* De Angeli & Beschin; p. 33
2003 – *Harpactocarcinus punctulatus* (Desmarest) *in* Schweitzer; p. 1118
2004 – *Harpactocarcinus punctulatus* (Desmarest) *in* Beschin & De Angeli; p. 20

Holotype: unknown.
Stratigraphic range: lower/upper Eocene (Ypresian – Priabonian).
Occurrence: Veneto.
Material: Desmarest (1822), Catullo (1854), Reuss (1859), A. Milne Edwards (1862-1865), and Bittner (1875) reported this species from the Eocene of some localities of Veneto (repository and catalogue number unknown); De Gregorio (1895) reported seven specimens from Valrovina (Vicenza), Verona area, and Castelrotto di Valpolicella (repository and catalogue number unknown); Checchia-Rispoli (1904) reported some specimens from Peschici (Puglia) (repository and catalogue number unknown); Fabiani (1910a) reported this species from some localities (Nanto, Mossano, and Barbarano – Monti Berici; S. Floriano, Lavacille, and Valrovina – Vicenza) (repository and catalogue number unknown); Piccoli & Mocellin (1962) reported one specimen (MGPD 1130) from Priabona (Vicenza).
Note: this species is also reported from the Eocene of Spain, France, Hungary, Switzerland, Istria, and Albany.

Harpactocarcinus spec.?

1875 – *Harpactocarcinus spec.? in* Bittner; p. 88, Pl. 3 (fig. 3)

Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Bittner (1875) reported one specimen from Sangonini di Lugo (Vicenza) (repository and catalogue number unknown).

Harpactoxanthopsis Via Boada, 1959

Type species: *Cancer quadrilobatus* Desmarest, 1822.
Stratigraphic range: Eocene.

Harpactoxanthopsis quadrilobata (Desmarest, 1822)

1822 – *Cancer quadrilobatus* Desmarest; p. 93, Pl. 8 (figs. 1-2)
1846 – *Cancer kressenbergensis* v. Meyer; p. 462, **nov. syn.**
1847 – *Cancer quadrilobatus* Desmarest *in* Delbos; p. 716
1850 – *Cancer quadrilobatus* Desmarest *in* d'Archiac; p. 448
1852 – *Cancer kressenbergensis* v. Meyer *in* v. Meyer; p. 32
1959 – *Cancer quadrilobatus* Desmarest *in* Reuss; p. 81
1862 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* A. Milne Edwards; p. 74, Pl. 3 (fig. 2), Pl. 4, (fig. 1), Pl. 5 (fig. 1)
1862 – *Xanthopsis kressenbergensis* (v. Meyer) *in* v. Meyer; p. 156, Pl. 16 (Figs. 12, 14)
1863 – *Xanthopsis kressenbergensis* (v. Meyer) *in* A. Milne Edwards; p. 323, Pl. 5 (fig. 3)
1863 – *Xanthopsis kressenbergensis* (v. Meyer) *in* Schafhäult; p. 226, Pl. 60 (fig. 7)
1864 – *Cycloxanthus quadrilobatus* (Desmarest) *in* Jacquot; p. 27
1875 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Bittner; p. 89, Pl. 2 (figs. 4-5), Pl. 3 (figs. 1-2)
1883 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Bittner; p. 312
1895 – *Cancer (Palaeocarpilius) gecchelinensis* De Gregorio; p. 14, Pl. 4 (fig. 3), **nov. syn.**
1898 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Lörenthey; p. 12
1905 – *Xanthopsis kressenbergensis* (v. Meyer) *in* Airaghi; p. 206, Pl. 4 (figs. 4-5)
1909 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Toniolo; p. 292, Pl. 26 (fig. 4)
1910a – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Fabiani; p. 25
1910a – *Xanthopsis kressenbergensis* (v. Meyer) *in* Fabiani; p. 26
1912 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Vogl; p. 106
1915 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Fabiani; p. 284, 285
1915 – *Xanthopsis kressenbergensis* (v. Meyer) *in* Fabiani; p. 285
1925 – *Xanthopsis kressenbergensis* (v. Meyer) *in* Schlosser; p. 144
1929 – *Harpactocarcinus quadrilobatus* (Desmarest) *in* Glaessner; p. 205
1929 – *Xanthopsis quadrilobata* (Desmarest) *in* Lörenthey & Beurlen; p. 208, Pl. 9 (figs. 3-4), Pl. 10 (fig. 7)
1959 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Via Boada; p. 54
1962 – *Xanthopsis kressenbergensis* (v. Meyer) *in* Piccoli & Mocellin; p. 77, Pl. 4 (fig. 18)
1968 – *Harpactoxanthopsis quadrilobatus* (Desmarest) *in* Vogeltanz; p. 37
1969 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Via Boada; p. 276, Pl. 30 (figs. 1-2), Pl. 31 (figs. 1-2) Pl. 32 (fig. 33)
1969 – *Harpactoxanthopsis kressenbergensis* (v. Meyer) *in* Via Boada; p. 284
1982 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Busulini, Tessier & Visentin; p. 80

1989 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Solè & Via Boada; p. 29
1994 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Beschin, Busulini, De Angeli & Tessier; p. 186, Pl. 8 (fig. 1 a-b)
1998 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Beschin, Busulini, De Angeli, Tessier & Ungaro; p. 24, Text-figs. 9 (5), 12, 13, 15 (1)
1998 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Müller; p. 33
2000 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Beschin, De Angeli & Alberti; p. 15
2000 – *Harpactoxanthopsis kressenbergensis* (v. Meyer) *in* Beschin, De Angeli & Alberti; p. 15
2001 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* De Angeli & Beschin; p. 34, Text-figs. 28-29
2001 – *Harpactoxanthopsis kressenbergensis* (v. Meyer) *in* De Angeli & Beschin; p. 34
2003 – *Harpactoxanthopsis quadrilobatus* (Desmarest) *in* Schweitzer; p. 1119
2004 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Beschin, Busulini, De Angeli & Tessier; p. 115
2004 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Beschin & De Angeli; p. 20
2005 – *Harpactoxanthopsis quadrilobata* (Desmarest) *in* Beschin, De Angeli, Checchi & Zarantonello; p. 23

Holotype: MNHN R03824 (syntype), MNHN R03817 (figured).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Desmarest (1822), Reuss (1859), A. Milne Edwards (1862-1865), Bittner (1875, specimen from Bittner, 1875 = MNHB MB.A. 662), and De Gregorio (1895) reported this species from the Eocene of some localities of Veneto (repository and catalogue number unknown); Airaghi (1905) reported two specimens (*H. kressembergensis*) (MGPD, 7476) from Priabona and Val di Lonte (=Val di Lonta *in* Airaghi) (Vicenza); Piccoli & Mocellin (1962) reported one specimen (MGPD 1123) from Valico di Priabona (Vicenza); Busulini *et al.* (1982) reported two specimens from "Main" quarry of Arzignano (Vicenza) (repository and catalogue number unknown); Beschin *et al.* (1994) reported three specimens (MCZ 1200, 1432, 1450) from "Boschetto" quarry of Nogarole Vicentino (Vicenza); Beschin *et al.* (1998) reported nine specimens (MCZ 1198, 1199, 1257, 1355, 1356, 1528, 1529, 1530, 1531) from "Rossi" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the Eocene of Spain, France, Germany, Austria, Hungary, Croatia, and Albany.

Harpactoxanthopsis cfr. *H. quadrilobata* (Desmarest, 1822)

2005 – *Harpactoxanthopsis* cfr. *H. quadrilobata in* Beschin, De Angeli, Checchi & Zarantonello; p. 23, Pl. 4 (fig. 4)

Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (2005) reported two specimens (MCZ 2311, 2378) from Grola di Cornedo Vicentino (Vicenza).

Harpactoxanthopsis souverbiei (A. Milne Edwards, 1862)

1862 – *Harpactocarcinus souverbiei* A. Milne Edwards; p. 72, Pl. 6 (figs. 3-5)
1875 – *Harpactocarcinus souverbiei* A. Milne Edwards *in* Bittner; p. 88
1909 – *Harpactocarcinus souverbiei* A. Milne Edwards *in* Toniolo; p. 293, Pl. 26 (fig. 5)
1929 – *Harpactocarcinus souverbiei* A. Milne Edwards *in* Glaessner; p. 206
1969 – *Harpactoxanthopsis souverbiei* (A. Milne Edwards) *in* Via Boada; p. 300, 383
2000 – *Harpactoxanthopsis souwerbiei* (A. Milne Edwards) *in* Beschin, De Angeli & Alberti; p. 15
2003 – *Harpactoxanthopsis souwerbiei* (A. Milne Edwards) *in* Schweitzer; p. 1119

Holotype: MNHN R03823 (syntype).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Bittner (1875) reported this species from Verona area (repository and catalogue number unknown)
Note: this species is also reported from the Eocene of S France and Istria (Croazia).

Neozanthopsis Schweitzer, 2003

Type species: *Harpactocarcinus americanus* Rathbun, 1928.
Stratigraphic range: Eocene.

Neozanthopsis bruckmanni (v. Meyer, 1862)

1859 – *Xanthopsis hispidiformis in* Reuss; p. 46, Pl. 12 (fig. 3), Pl. 13 (fig. 6), Pl. 14 (figs. 1-4), Pl. 23 (figs. 3-5)
1862 – *Xanthopsis Bruckmanni* v. Meyer; p. 152, Pl. 16 (figs. 5-11), Pl. 17 (figs. 1.3)
1863 – *Xanthopsis Bruckmanni* v. Meyer *in* A. Milne Edwards; p. 322, Pl. 7 (figs. 3-4)
1863 – *Xanthopsis Andreae* Schafhäutl; p. 229, Pl. 61 (figs. 2-3)
1863 – *Xanthopsis Grüntensis* Schafhäutl; p. 228, Pl. 62 (fig. 4)
1863 – *Xanthopsis sonthofensis* v. Meyer *in* Schafhäutl; p. 227, Pl. 61 (figs. 5-6?)
1877 – *Xanthopsis sonthofensis* v. Meyer *in* Mayer; p. 97
1925 – *Xanthopsis Bruckmanni* v. Meyer *in* Schlosser; p. 144
1929 – *Xanthopsis Bruckmanni* v. Meyer *in* Glaessner; p. 396
1930 – *Xanthopsis Bruckmanni* v. Meyer *in* Glaessner; p. 159
1959 – *Xanthopsis Bruckmanni* v. Meyer *in* Via Boada; p. 383
1969 – *Xanthopsis Bruckmanni* v. Meyer *in* Via Boada; p. 270, Text-fig. 32, Pl. 29 (figs. 1-3)
1973 – *Xanthopsis bruckmanni* v. Meyer *in* Via Boada; p. 62
1989 – *Zanthopsis bruckmanni* (v. Meyer) *in* Solé & Via Boada; p. 32
2000 – *Zanthopsis bruckmanni* (v. Meyer) *in* Beschin, De Angeli & Alberti; p. 14, Pl. 1 (figs. 1-4)
2001 – *Zanthopsis bruckmanni* (v. Meyer) *in* De Angeli & Beschin; p. 35, Text-fig. 30
2003 – *Neozanthopsis bruchmanni* (v. Meyer) *in* Schweitzer; p. 1119
2004 – *Neozanthopsis bruckmanni* (v. Meyer) *in* Beschin & De Angeli; p. 20

Holotype: unknown.
Stratigraphic range: lower Eocene (Ypresian).

Occurrence: Veneto.
Material: Beschin *et al.* (2000) reported one specimen (MCZ 1648) from "Rossi" quarry of Monte di Malo (Vicenza).
Note: this species is also reported from the Eocene of Austria, Switzerland, Germany and Spain.

Superfamily Potamoidea Ortmann, 1896
Family Potamidae Ortmann, 1896

Potamon Savigny, 1816

Type species: *Potamon fluviatilis* Savigny, 1816.
Stratigraphic range: upper Miocene – Recent.

?*Potamon castellinense* (Szombathy, 1916)

1874 – *Pseudothelphusa speciosa* Capellini; p. 39, Pl. 7 (figs. 1-2)
1885 – *Pseudothelphusa speciosa* Capellini *in* Mercanti; p. 214, Pl. 2 (fig. 15)
1904 – *Pseudothelphusa speciosa* Capellini *in* Capellini; p. 231
1916 – *Pseudothelphusa speciosa* Capellini *in* Rathbun; p. 415
1929 – *Potamon? castellinense* (Szombathy) *in* Glaessner; p. 337

Stratigraphic range: Miocene.
Occurrence: Toscana.
Material: Capellini (1874) reported this species from Valle del Marmolaio (Livorno) (repository and catalogue number unknown).

Subsection Thoracotremata Guinot, 1977
Superfamily Pinnotheroidea De Haan, 1833
Family Pinnotheridae De Haan, 1833

Asthenognathus Stimpson, 1858

Type species: *Asthenognatus inaequipes* Stimpson, 1858, by original designation.
Stratigraphic range: Oligocene – Recent.

Asthenognathus laverdensis De Angeli & Garassino, 2006

2006b – *Asthenognathus laverdensis* De Angeli & Garassino; p. 297, Text-figs. 2-4

Holotype: MSNM i26744.
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli & Garassino (2006b) reported 15 specimens (MSNM from i26745 to i26752; MCZ from 2467 to 2472) from Laverda (Vicenza).

Superfamily Ocypodoidea Rafinesque-Schmaltz, 1815
Family Ocypodidae Rafinesque-Schmaltz, 1815

Archaeocypoda Secretan, 1975

Type species: *Archaeocypoda veronensis* Secretan, 1975.
Stratigraphic range: middle Eocene (Lutetian).

Archaeocypoda veronensis Secretan, 1975

1975 – *Archaeocypoda veronensis* Secretan; p. 363, Text-figs. 21-22, Pls. 23 (2), 24, 25

Holotype: MSNM i45 (45bis).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Secretan (1975) reported three specimens (MSNM i45, i46, 103) from Monte Bolca (Verona).

Family Palicidae Bouvier, 1898

Eopalicus Beschin, Busulini, De Angeli & Tessier, 1996

Type species: *Eopalicus squamosus* Beschin, Busulini, De Angeli & Tessier, 1996.
Stratigraphic range: middle Eocene (Lutetian) – lower Oligocene (Rupelian).

Eopalicus imbricatus De Angeli & Beschin, 2000

2000 – *Eopalicus imbricatus* De Angeli & Beschin; p. 9, Text-fig. 3 (2), Pl. 1 (figs. 4-6)
2001 – *Eopalicus imbricatus* De Angeli & Beschin *in* De Angeli & Beschin; p. 40, Text-fig. 34 (2)
2003 – *Eopalicus imbricatus* De Angeli & Beschin *in* Beschin & De Angeli; p. 11

Holotype: MCZ 2034 (I.G. 286288).
Stratigraphic range: middle/upper Eocene (Bartonian – Priabonian).
Occurrence: Veneto.
Material: De Angeli & Beschin (2000) reported 24 specimens (MCZ from 2034 to 2057) from "Alonte" quarry (Vicenza).

Eopalicus semicarinatus De Angeli & Beschin, 2000

2000 – *Eopalicus semicarinatus* De Angeli & Beschin; p. 10, Text-fig. 3 (3), Pl. 1 (fig. 3)
2001 – *Eopalicus semicarinatus* De Angeli & Beschin *in* De Angeli & Beschin; p. 40, Text-fig. 34 (3)
2003 – *Eopalicus semicarinatus* De Angeli & Beschin *in* Beschin & De Angeli; p. 11

Holotype: MCZ 2058 (I.G. 286312).
Stratigraphic range: lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: De Angeli & Beschin (2000) reported one specimen (MCZ 2058) from Monte Lungo (Vicenza).

Eopalicus squamosus Beschin, Busulini, De Angeli & Tessier, 1996

1996a – *Eopalicus squamosus* Beschin, Busulini, De Angeli & Tessier; p. 77, Text-fig. 2, Pl. 1 (figs. 1-3)
2000 – *Eopalicus squamosus* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 8, Text-fig. 3 (1), Pl. 1 (figs. 1-2)
2001 – *Eopalicus squamosus* Beschin, Busulini, De Angeli & Tessier *in* De Angeli & Beschin; p. 39, Text-fig. 34 (1)
2003 – *Eopalicus squamosus* Beschin, Busulini, De Angeli & Tessier *in* Beschin & De Angeli; p. 11

2004 – *Eopalicus squamosus* Beschin, Busulini, De Angeli & Tessier *in* Beschin, Busulini, De Angeli & Tessier; p. 115

Holotype: MCZ 1479 (I.G. 286354).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Beschin *et al.* (1996a) reported six specimens (MCZ 1280, from 1479 to 1483) from "Main" quarry of Arzignano (Vicenza) and "Albanello" quarry of Nogarole Vicentino (Vicenza); De Angeli & Beschin (2000) reported two specimens (MCZ 2032, 2033) from "Main" quarry of Arzignano (Vicenza).

Spinipalicus Beschin & De Angeli, 2003

Type species: *Spinipalicus italicus* Beschin & De Angeli, 2003.
Stratigraphic range: middle – upper Eocene (Lutetian – Priabonian).

Spinipalicus italicus Beschin & De Angeli, 2003

2003 – *Spinipalicus italicus* Beschin & De Angeli; p. 9, Text-figs. 2-4

Holotype: MCZ 2390 (I.G. 296609).
Stratigraphic range: middle – upper Eocene (Lutetian – Priabonian).
Occurrence: Veneto.
Material: Beschin & De Angeli (2003) reported four specimens (MCZ 2390, 2391, 2392, 2393) from "Lovara" quarry of Chiampo, Nanto, and Alonte quarry (Vicenza).

Superfamily Grapsoidea MacLeay, 1838
Family Grapsidae MacLeay, 1838

Daragrapsus Müller & Collins, 1991

Type species: *Daragrapsus trispinosus* Müller & Collins, 1991.
Stratigraphic range: Eocene – Oligocene.

Daragrapsus trispinosus Müller & Collins, 1991

1991 – *Daragrapsus trispinosus* Müller & Collins; p. 88, Text-fig. 5 h, Pl. 7 (figs. 9-10, 12-14)
2001 – *Daragrapsus trispinosus* Müller & Collins *in* Beschin, De Angeli & Checchi; p. 28, Text-fig. 9, Pl. 3 (figs. 5-6)
2001 – *Daragrapsus trispinosus* Müller & Collins *in* De Angeli & Beschin; p. 38
2001 – *Daragrapsus trispinosus* Müller & Collins *in* Karasawa & Kato; p. 271, 272

Holotype: MAFI EK-30.1 (M.91-209).
Stratigraphic range: upper Eocene (Priabonian) – lower Oligocene (Rupelian).
Occurrence: Veneto.
Material: Beschin *et al.* (2001) reported eight specimens (MCZ 2066, 2067, 2071, 2072, 2073, 2074, 2117, 2124) from Castelgomberto (Vicenza).
Note: this species is also reported from the upper Eocene (Priabonian) of Hungary.

Daranyia Lörenthey, 1901

Type species: *Daranyia granulata* Lörenthey, 1901.
Stratigraphic range: upper Eocene (Priabonian).

Daranyia fabianii Di Salvo, 1933

1933 – *Daranyia Fabianii* Di Salvo; p. 40, Pl. 2 (figs. 5 a-d)

Holotype: MGUP 2620.
Stratigraphic range: upper Eocene (Priabonian).
Occurrence: Sicilia.
Material: Di Salvo (1933) reported one specimen (MGUP 2620) from Bichinello (Palermo).

Grapsus Lamarck, 1801

Type species: *Cancer grapsus* Linnaeus, 1758.
Stratigraphic range: Miocene – Recent.

Grapsus sp.

1889 – *Grapsus* sp. *in* Ristori; p. 402, Pl. 15 (figs. 2-3)
1974 – *Grapsus* sp. *in* Mastrorilli; p. 4

Stratigraphic range: Miocene.
Occurrence: Liguria.
Material: Ristori (1889) reported two specimens from Sassello (Savona), housed in don Perrando's collection, today lost.

Pseudodaranyia Tessier, Beschin, Busulini & De Angeli, 1999

Type species: *Pseudodaranyia carinata* Tessier, Beschin, Busulini & De Angeli, 1999.
Stratigraphic range: middle Eocene (Lutetian).

Pseudodaranyia carinata Tessier, Beschin, Busulini & De Angeli, 1999

1999 – *Pseudodaranyia carinata* Tessier, Beschin, Busulini & De Angeli; p. 99, Text-fig. 4, Pl. 2 (figs. 4-5)
2001 – *Pseudodaranyia carinata* Tessier, Beschin, Busulini & De Angeli *in* De Angeli & Beschin; p. 39
2004 – *Pseudodaranyia carinata* Tessier, Beschin, Busulini & De Angeli *in* Beschin, Busulini, De Angeli & Tessier; p. 116

Holotype: MCZ 1599 (I.G. 284666).
Stratigraphic range: middle Eocene (Lutetian).
Occurrence: Veneto.
Material: Tessier *et al.* (1999) reported two specimens (MCZ 1599, 1600) from "Main" quarry of Arzignano (Vicenza).

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BIBLIOGRAPHY

Airaghi C., 1905 – Brachiuri nuovi o poco noti pel Terziario Veneto. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 44: 202-209.

Allasinaz A., 1987 – Brachyura Decapoda oligocenici (Rupeliano) del Bacino Ligure Piemontese. *Bollettino del Museo regionale di Scienze naturali di Torino*, Torino, 5 (2): 509-566.

Ancona L., 1966 – Esemplari di Ranina (Decapodi, Brachiuri) eccezionalmente ben conservati nell'Eocene medio della Valle del Chiampo (Vicenza). *Memorie del Museo Civico di Storia Naturale di Verona*, Verona, 14: 401-408.

Beschin C., Busulini A., De Angeli A. & Tessier G., 1985 – Il genere *Micromaia* Bittner (Crustacea, Decapoda) nel Terziario dell'area dei Berici e dei Lessini, con descrizione di tre nuove specie. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 10: 97-119.

Beschin C., Busulini A., De Angeli A. & Tessier G., 1988 – Raninidae del Terziario berico-lessineo (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 13: 155-215.

Beschin C., Busulini A., De Angeli A. & Tessier G., 1994 – I Crostacei eocenici della cava "Boschetto" di Nogarole Vicentino (Vicenza - Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 19: 159-215.

Beschin C., Busulini A., De Angeli A. & Tessier G., 1996a – *Eopalicus* nuovo genere di brachiuro (Decapoda) del Terziario Veneto (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 21: 75-82.

Beschin C., Busulini A., De Angeli A. & Tessier G., 1996b – *Retroplumoidea* (Crustacea, Brachyura) nel Terziario del Vicentino (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 21: 83-102.

Beschin C., Busulini A., De Angeli A. & Tessier G., 2002 – Aggiornamento ai crostacei eocenici di cava "Main" di Arzignano (Vicenza, Italia settentrionale) (Crustacea, Decapoda). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2002: 7-28.

Beschin C., Busulini A., De Angeli A. & Tessier G., 2004 – The Eocene decapod crustacean fauna of the "Main" quarry in Arzignano (Vicenza - NE Italy) with the description of a new species of Raninidae. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 29: 109-117.

Beschin C., Busulini A., De Angeli A., Tessier G. & Ungaro S., 1991 – Due nuovi generi di Raninidae dell'Eocene del Veneto (Italia). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 16: 187-212.

Beschin C., Busulini A., De Angeli A., Tessier G. & Ungaro S., 1998 – Crostacei eocenici di "Cava Rossi" presso Monte di Malo (Vicenza - Italia settentrionale). *Studi Trentini di Scienze Naturali - Acta Geologica*, Trento, 73 (1996): 7-34.

Beschin C., Busulini A., De Angeli A., Tessier G. & Ungaro S., 2000 – The fauna of the Gecchelina quarry at Monte di Malo (Vicenza – Northern Italy): a preliminary study. *Extended abstracts – Studi e Ricerche – Associazione Amici Museo Zannato – Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2000: 7-10.

Beschin C., Checchi A. & Ungaro S., 1996 – Crostacei brachiuri dell'Oligocene di Castelgomberto (Lessini orientali). *Studi e Ricerche – Associazione Amici Museo Zannato – Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1996: 11-20.

Beschin C. & De Angeli A., 1984 – Nuove forme di Anomura Hippidea: *Albunea cuisiana* sp. n. e *Albunea lutetiana* sp. n. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 9 (1): 93-105.

Beschin C. & De Angeli A., 2003 – *Spinipalicus italicus*, nuovo genere e specie di Palicidae (Crustacea, Decapoda) dell'Eocene del Vicentino (Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2003: 7-12.

Beschin C. & De Angeli A., 2004 – Nuovi brachiuri eocenici dei Monti Lessini vicentini (Italia nordorientale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 11: 13-22.

Beschin C., De Angeli A. & Alberti R., 2000 – *Zanthopsis bruckmanni* (Meyer) (Crustacea, Decapoda) dell'Eocene del Vicentino (Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2000: 13-16.

Beschin C., De Angeli A. & Checchi A., 2001 – Crostacei decapodi associati a coralli della "Formazione di Castelgomberto" (Oligocene) (Vicenza - Italia Settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2001: 13-30.

Beschin C., De Angeli A., Checchi A. & Mietto P., 2006 – Crostacei del Priaboniano di Priabona (Vicenza - Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 31: 95-112.

Beschin C., De Angeli A., Checchi A. & Zarantonello G., 2005 – Crostacei eocenici di Grola di Cornedo Vicentino presso Spagnago (Vicenza, Italia Settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 12: 5-35.

Beschin C., De Angeli A. & Garassino A., 2001 – *Justitia vicetina* n. sp. (Crustacea, Decapoda) dell'Eocene di Chiampo (Vicenza, Italia settentrionale). *Studi Trentini di Scienze Naturali - Acta Geologica*, Trento, 76 (1999): 89-97.

Beschin C. & Garassino A., 1999 – *Penaeus vanzii* n. sp. e *Penaeus sorbinii* n. sp. (Crustacea, Decapoda) dell'Oligocene della Valle del Ponte (Laverda) e Salcedo (Vicenza, N. Italia). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 140 (2): 189-208.

Beschin C. & Santi L., 1997 – *Cancer sismondai* Meyer (Crustacea, Decapoda) nelle argille plioceniche di Vignola sul Panaro (Modena). *Studi e Ricerche - Associazione Amici Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1997: 11-16.

Bittner A., 1875 – Die Brachyuren des Vicentinischen Tertiärgebirges. *Denkschriften Akademie Wissenschaften*, Wien, 34: 63-106.

Bittner A., 1883 – Neue Beiträge zur Kenntniss der Brachyuren-Fauna des Altertiärs von Vicenza und Verona. *Denkschriften Akademie Wissenschaften*, Wien, 46: 299-316.

Bittner A., 1884 – Beiträge zur Kenntniss tertiärer Brachyuren-Faunen. *Denkschriften Akademie Wissenschaften*, Wien, 48: 15-30.

Bittner A., 1886 – Neue Brachyuren des Eocäens von Verona. *Sitzungsberichte Akademie Wissenschaften*, Wien, 94: 44-55.

Bittner A., 1895 – Über zwei ungenügend bekannte brachyure Crustaceen des Vicentinischen Eocäns. *Sitzungsberichte Akademie Wissenschaften.*, Wien, 104: 247-253.

Boyko C. B., 2004 – A new genus of fossil sand crab (Amonura: Albuneidae) from the Oligocene of Italy. *Palaeontology*, London, 47 (4): 933-936.

Bonfiglio L. & Donadeo G., 1982 – *Cancer sismondai* Meyer nel Pliocene di Torre dell'Orso (Puglia). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 123: 255-296.

Bortoluzzi S., 2002 – Invertebrati del limite Plio-Pleistocene di Strongoli (KR): preparazione, studio e valorizzazione. Università degli Studi di Padova (unpublished degree).

Bravi S. & Garassino A., 1998a – New biostratigraphic and palaeoecologic observations on the "Plattenkalk" of the Lower Cretaceous (Albian) of Pietraroia (Benevento, S Italy), and its decapod crustacean assemblage. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 138: 119-171.

Bravi S. & Garassino A., 1998b – "Plattenkalk" of the Lower Cretaceous (Albian) of Petina, in the Alburni Mounts (Campania, S Italy) and its decapod crustacean assemblage. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 138: 89-118.

Bravi S., Coppa M. G., Garassino A. & Patricelli R., 1999 – *Palaeomon vesolensis* n. sp. (Crustacea, Decapoda) from the Plattenkalk of Vesole Mount (Salerno, S Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 140 (2): 141-169.

Busulini A., Tessier G., Beschin C. & De Angeli A., 2003 – *Boschettia giampietroi*, nuovo genere e specie di Portunidae (Crustacea, Decapoda) dell'Eocene medio della Valle del Chiampo (Vicenza, Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2003: 13-18.

Busulini A., Tessier G. & Visentin M., 1982 – Brachyura della cava Main (Arzignano) - Lessini orientali (Vicenza) (Crustacea, Decapoda). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 7: 75-84.

Busulini A., Tessier G. & Visentin M., 1984 – *Titanocarcinus aculeatus* nuova specie di brachiuro nell'Eocene del Veneto (Crustacea, Decapoda). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 9 (1): 107-117.

Busulini A., Tessier G., Visentin M., Beschin C., De Angeli A. & Rossi A., 1983 – Nuovo contributo alla conoscenza dei brachiuri Eocenici di Cava Main (Arzignano) - Lessini Orientali (Vicenza). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 8: 55-73.

Capellini G., 1874 – La Formazione Gessosa di Castellina Marittima e i suoi fossili. *Memorie dell'Accademia di Scienze Istituzionali di Bologna,* Bologna, 3 (4): 1-60.

Catullo T. A., 1854 – Sui Crostacei fossili della calcaria grossolana del veronese. «Lettera al Signor Professore O. F. Naumann di Lipsia». *Annuario Reale Istituto Geologico Vienna.*

Checchia-Rispoli G., 1903 – Sopra un crostaceo dei Tufi calcarei Post-Pliocenici dei dintorni di Palermo. *Bollettino della Società Geologica Italiana*, Roma, 22: 488-492.

Checchia-Rispoli G., 1904 – L'*Harpactocarcinus punctulatus* Desm. dell'Eocene di Peschici nel Monte Gargano. *Bollettino della Società Zoologica Italiana,* Roma 2 (5): 49-57.

Checchia-Rispoli G., 1905 – I crostacei dell'Eocene dei dintorni di Monreale in provincia di Palermo. *Giornale di Scienze Naturali ed Economiche di Palermo*, Palermo, 25: 309-325.

Checchia-Rispoli G., 1907 – Sopra un crostaceo dell'Eocene medio dei dintorni di Bagheria in Provincia di Palermo. *Bollettino della Società Geologica Italiana*, Roma, 26 (1): 25-28.

Checchia-Rispoli G., 1914 – "*Distefania*" nuovo genere di Brachiuri del Cenomaniano della Sicilia. *Bollettino della Società Zoologica Italiana*, Roma, ser. 3, 3 (12): 173-184.

Collins J. S. H. & Dieni I., 1995 – New decapod crustaceans from the Cenomanian Rudist Limestones of NE Italy. *Bulletin of Mizunami Fossil Museum*, Mizunami, 22: 67-72.

Colosi G., 1921 – Un nuovo crostaceo fossile: "*Heteroglyphea paronae*". *Atti della Reale Accademia di Scienze di Torino*, Torino, 56: 79-82.

Comaschi Caria I., 1950 – Crostacei decapodi nel Miocene (Elveziano) di Bosa in Sardegna. *Rendiconti del Semimario della Facoltà di Scienze dell'Univesità di Cagliari*, Cagliari, 20 (3-4): 324-327.

Comaschi Caria I., 1956 – I crostacei miocenici della Sardegna. *Bollettino del Servizio Geologico d'Italia*, Roma, 28 (1-2): 283-290.

Crema C., 1895 – Sopra alcuni decapodi terziarii del Piemonte. *Atti della Reale Accademia di Scienze di Torino*, Torino, 30: 664-681.

Dainelli G., 1915 – L'Eocene Friulano - Monografia geologica e paleontologica. *Editrici le "Memorie Geografiche"*, Firenze.

Dalla Vecchia F. M., 1991 – Note sulla stratigrafia, sedimentologia e paleontologia della Dolomia di Forni (Triassico superiore) nella Valle del Rio Seazza (Preone, Friuli-Venezia Giulia). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 12 (1990): 7-30.

Dalla Vecchia F. M., 1993 – Segnalazione di crostacei nell'Unità Fonte Santa (Triassico sup.) presso Filettino (Lazio, Italia). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 14 (1992): 59-69.

De Angeli A., 1995 – Crostacei dell'Eocene superiore di "Fontanella" di Grancona (Vicenza - Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1995: 7-24.

De Angeli A., 1997 – *Lysiosquilla messinae*, nuova specie di crostaceo stomatopode del Terziario di Vicenza (Nord Italia). *Studi e Ricerche - Associazione Amici Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1997: 23-26.

De Angeli A., 1998 – Gli *Albuneidae* (Crustacea, Hippoidea) del Terziario vicentino (Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1998: 17-20.

De Angeli A. & Beschin C., 1998 – *Ceronnectes*, nuovo genere di brachiuro (Crustacea, Decapoda) dell'Eocene di Ungheria e Italia. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 23: 87-91.

De Angeli A. & Beschin C., 1999 – I crostacei Matutinae (Brachyura, Calappidae) dell'Eocene del Veneto (Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1999: 11-22.

De Angeli A. & Beschin C., 2000 – Due nuove specie di *Eopalicus* (Decapoda, Palicidae) nel Terziario del Veneto (Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2000: 7-12.

De Angeli A. & Beschin C., 2001 – I Crostacei fossili del territorio Vicentino. *Natura Vicentina*, Vicenza, 5: 5-54.

De Angeli A. & Beschin C., 2002 – *Branchioplax albertii*, nuova specie di Goneplacidae (Crustacea, Decapoda) dell'Eocene di cava "Main" di Arzignano (Vicenza - Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 27: 125-130.

De Angeli A. & Beschin C., 2004 – *Nucilobus bericus* sp. nov., nuovo crostaceo Leucosiidae dell'Eocene superiore del Veneto (Vicenza - Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 29: 119-122.

De Angeli A., Beschin C. & Checchi A., 2005 – Una nuova specie di Albuneidae Stimpson, 1858 dell'Eocene della Valle del Chiampo (Vicenza, NE Italia) e considerazioni sulle altre forme note (Decapoda, Anomura, Hippoidea). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 30: 85-91.

De Angeli & Garassino A., 2002 – Galatheid, chirostylid and porcellanid decapods (Crustacea, Decapoda, Anomura) from the Eocene and Oligocene of Vicenza (N Italy). *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 30 (3): 3-31.

De Angeli A. & Garassino A., 2003 – *Bittnerilia*, new genus for *Lambrus eocaenus* Bittner, 1883 (Decapoda, Brachyura, Calappidae) from the middle Eocene of Veneto (N Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 144 (1): 13-22.

De Angeli A. & Garassino A., 2006a – New report of decapod crustaceans from the Mesozoic and Cenozoic of Friuli-Venezia Giulia (NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (2): 267-294.

De Angeli A. & Garassino A., 2006b – *Asthenognathus laverdensis* n. sp. (Decapoda: Brachyura: Pinnotheridae) from the lower Oligocene of Laverda (Vicenza, NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (2): 295-304.

De Angeli A. & Marangon S., 1992 – *Necronectes schafferi* Glaessner, nel Miocene della Sardegna (Italia). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 17: 175-182.

De Angeli A. & Marangon S., 2001 – *Paralbunea galantensis*, nuova specie di anomuro oligocenico del Bacino Ligure-Piemontese (Italia settentrionale). *Studi Trentini Scienze Naturali - Acta Geologica*, Trento, 76 (1999): 99-105.

De Angeli A. & Marangon S., 2003a – Decapod crustaceans from the Oligocene of the Ligure Piemontese Basin, northern Italy. *Contributions to Zoology*, The Hague, 72 (2-3): 101-104.

De Angeli A. & Marangon S., 2003b – Contributo alla conoscenza dei Decapodi oligocenici del Bacino Ligure Piemontese (Italia settentrionale). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 144 (2): 185-196.

De Angeli A. & Messina V., 1992 – *Upogebia pererolensis* nuova specie di crostaceo del Terziario del Veneto. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 17: 183-191.

De Angeli A. & Messina V., 1996 – *Pseudosquilla berica* nuova specie di Stomatopoda del Terziario Veneto (Italia Settentrionale). *Studi e Ricerche – Associazione Amici Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1996: 5-10.

De Angeli A. & Messina V., 1997 – *Galatea weinfurteri* Bachmayer, 1950 (Crustacea, Anomura) nell'Oligocene di Perarolo (Vicenza, Nord Italia). *Studi e Ricerche – Associazione Amici Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1997: 17-21.

De Angeli A. & Rossi A., 2006 – Crostacei oligocenici di Perarolo (Vicenza - Italia settentrionale), con la descrizione di una nuova specie di Mysida e di Isopoda. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 31: 85-93.

De Gregorio A., 1884 – Nuovi Decapodi titonici. *Naturalista Siciliano*, Palermo, 3: 134.

De Gregorio A., 1894 – Description des faunes tertiaires de la Vénétie. Monographie des fossiles éocèniques (Etage Parisien) de Mont Postale. *Annales de Géologie et de Paléontologie*, Palermo, 14: 1-55.

De Gregorio A., 1895 – Note sur certains Crustacés (Brachiures) éocéniques. (Avec un catalogue de tous les Crustacés de la Vénetie cités par les Auteurs). *Annales de Géologie et de Paléontologie*, Palermo, 18: 1-22.

Delle Cave L., 1981 – Catalogue of type specimens in the invertebrate palaeontological collections of the Museum of Geology and Palaeontology of the University of Florence (Italy). Crustacea, Decapoda. *Atti della Società Toscana di Scienze Naturali*, Memorie, Pisa, serie A, 88: 43-50.

Delle Cave L., 1988a – *Jaxea* cf. *nocturna* (Crustacea, Decapoda, Anomura) from the Early Pliocene of Toscana, Italy. *Bollettino della Società Paleontologica Italiana*, Modena, 27 (1): 3-10.

Delle Cave L., 1988b – *Monodaeus bortolottii*, a new species of Brachyura (Crustacea, Decapoda) from the Pliocene of Toscana (Italy). *Bollettino della Società Paleontologica Italiana*, Modena, 27 (2): 123-127.

Desmarest A.-G., 1822 – Histoire Naturelle des Crustacés fossiles. Les crustacés proprement dits. *F.-G. Levrault*, Paris.

Di Salvo G., 1933 – I Crostacei del Terziario inferiore della provincia di Palermo. *Giornale Scienze Naturali ed Economiche di Palermo*, Palermo, 37: 1-44.

Fabiani R., 1908 – Paleontologia dei Colli Berici. *Memorie di Matematica e di Fisica della Società Italiana delle Scienze*, Roma, ser. 3, 15: 45-248.

Fabiani R., 1910a – I crostacei terziarii del Vicentino. *Bollettino del Museo Civico di Vicenza*, Vicenza, 1 (1): 1-40.

Fabiani R., 1910b – Sulle specie di *Ranina* finora note ed in particolare sulla *Ranina Aldrovandii*. *Atti della Accademia Veneto Trentino Istriana*, ser. 3, 3: 85-102.

Fabiani R., 1911 – Di una nuova specie di *Phlyctenodes* (*Phl. Dalpiazi*) dell'Oligocene dei Berici. *Bollettino del Museo Civico di Vicenza*, Vicenza, 1: 41-45.

Fabiani R., 1915 – Il Paleogene del Veneto. *Memorie dell'Istituto Geologico della Reale Università di Padova*, Padova, 3: 283-289.

Feldmann R. M., Bice K. L., Schweitzer Hopkins C., Salva E. W. & Pickford K., 1998 – Decapod crustaceans from the Eocene Castle Hayne Formation, North Carolina: paleoceanographic implications. *Journal of Paleontology,* Lawrence, Memoir 48: 1-28.

Förster R., 1984 – Bärenkrebse (Crustacea, Decapoda) aus dem Cenoman des Libanon und dem Eozän Italiens. *Mitteilung Bayerische Staatlische Paläontologische historische Geologische*, München, 24: 57-66.

Fucini A., 1910 – L'*Eriphia Cocchii* Rist. *Annali Università Toscana*, Firenze, 30: 1-5.

Garassino A., 1996 – The family Erymidae Van Straelen, 1924 and the superfamily Glypheoidea Zittel, 1885 in the Sinemurian of Osteno in Lombardia (Crustacea, Decapoda). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 135: 333-373.

Garassino A., 1997 – The species *Glyphea tonelloi* n. sp. (Crustacea, Decapoda) in the Lower Cretaceous (Upper Barremian-Aptian) of the Valley of Cornappo River (Udine, NE Italy). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 19: 85-93.

Garassino A., 1998 – New study on decapod crustaceans of the Lower Cretaceous (Barremian-Aptian) of the Valley of Cornappo River (Udine, NE Italy). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 20: 59-73.

Garassino A., 1999 – Nuova segnalazione di crostacei decapodi nel Cretacico inferiore di Vernasso (Udine, NE Italia). *Gortania – Atti del Museo Friulano di Storia Naturale*, Udine, 21: 61-64.

Garassino A. 2000a – *Glyphea rigoi* n. sp. (Crustacea, Decapoda) of Dolomia di Forni (Norian, Upper Triassic) of Carnia (Udine, NE Italy). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 22: 59-64.

Garassino A., 2000b – *Palinurus* sp. (Crustacea, Decapoda) del Cretacico inferiore (Barremiano-Aptiano) della Valle del Torrente Cornappo (Udine, NE Italia). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 22: 65-68.

Garassino A. & Bravi S., 2003 – *Palaemon antonellae* n. sp. (Crustacea, Decapoda, Caridea) from the Lower Cretaceous "Platydolomite" of Profeti (Caserta, S Italy). *Journal of Paleontology*, Lawrence, 77 (3): 589-592.

Garassino A. & De Angeli A., 2004a – Decapod crustacean fauna from the Pliocene and Pleistocene of Arda, Stirone and Fiume Enzas (Piacenza, Parma and Reggio Emilia Provinces, N. Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 145 (1): 29-57.

Garassino A. & De Angeli A., 2004b – *Parthenope angulifrons* Latreille, 1825, and *Atelecyclus rotundatus* (Olivi, 1792) from the Sicilian (upper Pleistocene) of Favignana Island (Egadi Islands, Sicilia, S Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 145 (1): 19-28.

Garassino A., De Angeli A. & De Polli R., 2003 – Report of *Metanephrops* Jenkins, 1972 (Crustacea, Decapoda, Nephropidae) from the upper Eocene of Grancona (Vicenza, N Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 144 (2): 383-392.

Garassino A., De Angeli A., Gallo L. M. & Pasini G., 2004 – Brachyuran and anomuran fauna from the Cenozoic of Piemonte (NW Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 145 (2): 251-281.

Garassino A. & Fornaciari A., 2000 – *Cancer sismondai* Meyer, 1843 (Crustacea, Decapoda) in the Pleistocene deposits of Fiume Enza (Parma, Italy). *Extended abstract - Studi e Ricerche - Associazione Amici Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 2000: 29-30.

Garassino A. & Gironi B., 2005 – *Proeryon hartmanni* (v. Meyer, 1835) (Crustacea, Decapoda, Eryonoidea) and *Archaeopalinurus* cfr. *A. levis* Pinna, 1974 (Crustacea, Decapoda, Palinuroidea) from the Lower Jurassic (Toarcian) of Cesana Brianza-Suello (Lecco, N Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 146 (1): 53-68.

Garassino A. & Gironi B., 2006 – *Coleia boboi* n. sp. (Crustacea, Decapoda, Coleiidae) from the Upper Triassic (Rhaetian) of Monte Verzegnis (Udine, NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (1): 93-102.

Garassino A. & Novati M., 2001 – *Justitia desmaresti* (Massalongo, 1854) (Crustacea, Decapoda) from the Lutetian (Middle Eocene) of Monte Bolca (Verona, N Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 141 (2): 251-268.

Garassino A. & Schweigert G., 2006 – The Upper Jurassic Solnhofen decapod crustacean fauna: review of the types from old description. Part I. Infraorders Astacidea, Thalassinidea and Palinura. *Memorie*

della Società italiana di Scienze Naturali e del Museo civico di Storia Naturale di Milano, Milano, 34 (1): 1-64.

Garassino A. & Teruzzi G., 1990 – The genus *Aeger* Münster, 1839 in the Sinemurian of Osteno in Lombardia (Crustacea, Decapoda). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 131 (5): 105-136.

Garassino A. & Teruzzi G., 1993 – A new decapod crustacean assemblage from the Upper Triassic of Lombardia (N. Italy). *Paleontologia Lombarda*, Nuova serie, Milano, 1: 3-27.

Garassino A. & Teruzzi G., 1995 – Decapod crustaceans from the Lower Cretaceous of Vernasso (Udine, NE Italy). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 16 (1994): 77-88.

Garassino A. & Teruzzi G., 2001 – I crostacei decapodi del Toarciano (Giurassico inferiore) di Sogno (Bergamo, N. Italia). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 141 (2): 187-197.

Garassino A., Teruzzi, G. & Dalla Vecchia F. M., 1996 – The macruran decapod crustaceans of the Dolomia di Forni (Norian, Upper Triassic) of Carnia (Udine, NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 136: 15-60.

Gemmellaro G. G., 1869 – Studi paleontologici sulla fauna del calcare a *Terebratula janitor* del Nord di Sicilia. Palermo, Parte I. *Stabilimento Tipografico Lao.*

Gemmellaro M., 1914 – Crostacei e pesci fossili del "Piano Siciliano" dei dintorni di Palermo. *Giornale di Scienze Naturali ed Economiche di Palermo*, Palermo, 30: 73-94.

Glaessner M. F., 1929 – Fossilium catalogus. I: Animalia. Crustacea decapoda. *J. F. Pompecky ed.*, Berlin.

Glaessner M. F., 1969 – Crustacea Decapoda. In: Treatise on Invertebrate Paleontology. Arthropoda 4 (2), Moore R. C., *Geological Society of America and University of Kansas*, Lawrence: R399-R533, R626-R628.

Karasawa H. & Kato H., 2001 – The systematic status of the genus *Miosesarma* Karasawa, 1989 with a phylogenetic analysis within the family Grapsidae and a review of fossil records (Crustacea: Decapoda: Brachyura). *Paleontological Research*, 5 (4): 259-275.

Larghi C., 2002 – *Mithracia oppionii* sp. nov. (Crustacea, Decapoda, Brachyura) from the Eocene of Chiampo (Vicenza, Italy). *Bulletin of Mizunami Fossil Museum*, Mizunami, 29: 61-68.

Larghi C., 2003 – First record of Oligocene retroplumid crab (Crustacea: Decapoda: Brachyura) from Italy. *Bulletin of Mizunami Fossil Museum*, Mizunami, 30: 57-60.

Lörenthey I., 1898 – Beiträge zur Decapodenfauna des Ungarischen Tertiärs. *Termész Füzetek*, Budapest, 21: 1-133.

Lörenthey I., 1907 – Adatok Sardínia harmadidöszaki rák-faunájához. *Mathematische Es Természettudomanyi Közlemenyek*, Budapest, 19 (2): 243-296.

Lörenthey I., 1909 – Beiträge zur Tertiären dekapodenfauna Sardiniens. *Mathematischen und Naturwissenschaftlichen Berichte aus Ungarn*, Budapest, 24: 202-257.

Lovisato D., 1894 – Avanzi di *Squilla* nel Miocene medio di Sardegna. *Rendiconti della Reale Accademia dei Lincei*, Roma, 3 (4): 205-209.

Lovisato D., 1902 – Le specie fossili finora trovate nel calcare compatto di Bonaria e di San Bartolomeo. *Tipo-Litografia Commerciale,* Cagliari: 1-21.

Malaroda R. 1950 – Il Lattorfiano del Montecchio di Custozza (Colli Berici). I. I macrofossili. *Memorie del Museo Civico di Storia Naturale di Verona*, Verona, 2: 147-215.

Marangon S. & De Angeli A., 1997 – *Cherpiocarcinus*, nuovo genere di brachiuro (Decapoda) dell'Oligocene del Bacino Ligure-Piemontese (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 22: 97-106.

Marras G. & Ventura G., 1991 – Crostacei decapodi del miocene di Sassari (Sardegna nord-occidentale). *Bollettino della Società Sarda di Scienze Naturali*, Sassari, 28: 105-119.

Martin J. W. & Davis G. E., 2001 – An Updated Classification of the Recent Crustacea. *Natural History Museum of Los Angeles County, Sciences Series*, Los Angeles, 39: 1-123.

Maxia C., 1946 – Su alcuni crostacei dei dintorni di Roma. *Bollettino del Reale Ufficio Geologico d'Italia*, Roma, 69 (7): 129-150.

Meneghini G., 1857 – Paléontologie de l'Ile de Sardaigne. In: A Voyage en Sardaigne, *Ed. La Marmora*, Torino.

Michelotti G., 1861 – Étude sur le miocène inferieur de l'Italie septentrionale. *Mémoire de la Société Hollandais des Sciences*, Paris.

Milne Edwards A., 1860 – Histoire des Crustacés Podophthalmaires fossiles. *Annales des Sciences Naturelles (Zoologie et Botanie), 4ieme serie Zoologie*, Paris, 14 (3): 129-293.

Milne Edwards A., 1861 – Remarques sur la faune carcinologique des Terrains quaternaires. *L'Institut*, Paris, 29: 88.

Milne Edwards A., 1862-1865 – Monographies des crustacés de la famille cancériens. *Annales des Sciences Naturelles (Zoologie et Botanie),* Paris, Serie 4, Volume 18 (1862): 31-85; Volume 20 (1863): 273-324; Serie 5, Volume 1 (1864): 31-88; Volume 31 (1865): 297-351.

Milne Edwards A., 1872 – Note sur quelques Crustacés fossiles appartenant aux genres *Ranina* et *Galenopsis*. *Annales Sciences Géologique*, Paris, 3, art. 3: 2, 8.

Milne Edwards H., 1850 – Formation nummulitique de l'Espagne. In: Histoire des progrés de la Géologie de 1834 á 1849. d'Archiac A. (ed.). Paris. 3: 1-304.

Müller P., 1993 – Neogene decapod crustaceans from Catalonia. *Scripta Museum Seminario Barcinonensis*, Barcelona, 225: 1-39.

Müller P. & Collins J. S. H., 1991 – Late Eocene coral-associated decapods (Crustacea) from Hungary. *Contributions to Tertiary and Quaternary Geology,* Budapest, 28: 47-92.

Münster G., von 1842 – Beschreibung drei neuer Arten Crustaciten. *Beiträge zur Petrefactenkunde*,. Bayreuth, 5.

Oppenheim P., 1901 – Die Priabonaschichten und ihre Fauna. *Paleontographica*, Stuttgart, 47: 1-348.

Oppenheim P., 1903 – Ueber die Ueberkippung von S. Orso, das Tertiär des Tretto und Fauna wie Stellung der Schioschichten. *Zeitschrift Deutschen Geologischen Gesellschaft*, Hannover, 55: 98-235.

Piccoli G. & Mocellin L. G., 1962 – Studi sulla macrofauna priaboniana di Priabona. *Memorie dell'Istituto Geologico e Mineralogico dell'Università di Padova*, Padova, 23: 3-120.

Pinna G., 1974 – I crostacei della fauna triassica di Cene in Val Seriana (Bergamo). *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 21 (1): 5-34.

Pinna G., 1976 – I crostacei triassici dell'Alta Valvestino. *"Natura Bresciana" - Annali del Museo Civico di Storia Naturale*, Brescia, 13: 33-42.

Pinna G., 1968 – Gli Erionidei della nuova fauna sinemuriana a crostacei decapodi di Osteno in Lombardia. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 107: 93-134.

Pinna G., 1969 – Due nuovi esemplari di *Coleia viallii* Pinna, del Sinemuriano inferiore di Osteno in Lombardia (Crustacea, Decapoda). *Annali del Museo di Storia naturale di Genova*, Genova, 77: 626-632.

Reuss A., 1859 – Zur Kenntniss fossiler Krabben. *Denkschriften der Akademie der Wissenschaften*, Wien, 17: 1-90.

Ristori G., 1886 – I crostacei brachiuri e anomuri del Pliocene italiano. *Bollettino della Società Geologica Italiana*, Roma, 5: 93-129.

Ristori G., 1888 – Alcuni crostacei del Miocene medio italiano. *Atti della Società Toscana di Scienze Naturali*, Pisa, 9: 212-219.

Ristori G., 1889 – Crostacei Piemontesi del Miocene Inferiore. *Bollettino della Società Geologica Italiana*, Roma, 7: 397-413.

Ristori G., 1891a – Contributo alla fauna carcinologica del Pliocene italiano. *Atti della Società Toscana di Scienze Naturali*, Pisa, 11: 3-18.

Ristori G., 1891b – I crostacei fossili di Monte Mario. *Atti della Società Toscana di Scienze Naturali*, Pisa, 11: 19-25.

Ristori G., 1892a – Note di Carcinologia pliocenica. *Atti della Società Toscana di Scienze Naturali*, processi verbali, Pisa, 8: 86-89.

Ristori G., 1892b – Resti di crostacei nel Pliocene dell'Isola di Pianosa. *Atti della Società Toscana di Scienze Naturali*, processi verbali, Pisa, 8: 90.

Ristori G., 1892c – I crostacei fossili di Chiavon. *Atti della Società Toscana di Scienze Naturali*, processi verbali, Pisa, 8: 160-163.

Ristori G., 1893 – Il *Titanocarcinus raulinianus* A. M. Edw. negli strati nummulitici del Gargano. *Atti della Società Toscana di Scienze Naturali*, Pisa, 7 (8): 212-215.

Ristori G., 1896 – Crostacei neogenici di Sardegna e di alcune altre località italiane. *Bollettino della Società Geolologica Italiana*, Roma, 15 (4): 504-513.

Rizzotto D., 1998 – Nuovo esemplare di *Cyrtorhina globosa* nell'Eocene medio della Valle del Chiampo (Vicenza). *Studi e Ricerche - Associazione Amici Museo Zannata - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1998: 21-24.

Ronzani C., 1818 – Osservazione sopra un fossile dell'Aldrovandi chiamato Sepite. *Memorie di Storia Naturale,* Bologna, 7: 76.

Schram F. R. & Müller H. G., 2004 – Catalog and bibliography of the fossil and recent stomatopoda. *Backhuys publishers*, Leiden.

Schweigert G., Garassino A., Hall R. L., Hauff R. B. and Karasawa H., 2003 – The Lower Jurassic lobster *Uncina* Quenstedt, 1851 (Crustacea: Decapoda: Astacidea: Uncinidae). *Stuttgarter Beiträge Naturkunde*, Stuttgart, Ser. B, 332: 1-20.

Schweitzer C. E., 2003 – Utility of proxy characters for classification of fossils: an example from the fossil Xanthoidea (Crustacea: Decapoda: Brachyura). *Journal of Paleontology*, Lawrence, 77 (6): 1107-1128.

Schweitzer C. E., Feldmann R. M., Gonzalea-Barba G. & Cosovic V., in press – New Decapoda (Anomura, Brachyura) from the Eocene Bateque and Tepetate formations, Baja California Sur, Mexico. *Bulletin of Mizunami Fossil Museum*, Mizunami.

Secretan S., 1975 – Les crustacés du Monte Bolca. *Museo civico Storia Naturale - Studi e Ricerche sui giacimenti terziari di Bolca*, Verona, 2: 315-346.

Sismonda A., 1839 – Notizie intorno a due fossili trovati nei colli di S. Stefano Roero. *Memorie della Reale Accademia di Scienze di Torino*, Torino, ser. 2, 1: 90-95.

Sismonda E., 1846 – Descrizione dei pesci e dei crostacei fossili nel Piemonte. *Memorie della Reale Accademia di Scienze di Torino*, Torino, ser. 2, 10: 1-89.

Sismonda E., 1861 – Appendice alla descrizione dei pesci e dei crostacei fossili. *Memorie della Reale Accademia di Scienze di Torino*, Torino, ser. 2, 19: 1-24.

Teruzzi G., 1990 – The genus *Coleia* Broderip, 1835 (Crustacea, Decapoda) in the Sinemurian of Osteno in Lombardia. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 131 (4): 85-104.

Tessier G., Beschin C., Busulini A. & De Angeli A., 1999 – Nuovi brachiuri eocenici della cava "Main" di Arzignano (Vicenza - Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 24: 93-105.

Tessier G., Busulini A., Beschin C. & De Angeli A., 2004 – Segnalazione di *Cyrtorhina globosa* Beschin, Busulini, De Angeli & Tessier, 1988 (Crustacea, Decapoda, Brachyura) nell'Eocene di Zovo di Bolca (Verona, Italia settentrionale). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 11 (2004): 7-12.

Tettoni W., 1923 – Crostacei pliocenici dell'Appennino Modenese. *Atti della Società Naturalisti e Matematici di Modena*, Modena, s. 6, 1 (53): 160-162.

Varola A., 1965 – Nota preliminare su di un giacimento a *Cancer sismondai* Meyer nella Provincia di Lecce. *Atti della Società Toscana di Scienze Naturali*, Pisa, ser. A, 72 (1): 295-298.

Varola A., 1981 – Crostacei decapodi neogenici della Provincia Salentina (Italia). *Thalassia Salentina*, 11: 3-51.

Via Boada L., 1959 – Decápodos fósiles del Eoceno español. *Boletín del Istituto Geológico y Minero de España,* Madrid, 70: 331-402.

Via Boada L., 1969 – Crustacéos Decápodos del Eoceno español. *Pirineos,* Barcelona, 91-94: 1-479.

Vicariotto G. & Beschin C., 1994 – *Galathea weinfurteri* Bachmayer nell'Oligocene dei Monti Berici (Italia settentrionale) (Crustacea, Anomura). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1994: 5-11.

Vicariotto M., 1997 – Nuovo contributo alla conoscenza dei crostacei fossili della cava "Boschetto" di Nogarole Vicentino (Vicenza, Nord Italia). *Studi e Ricerche - Associazione Amici Museo Zannato - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1997: 27-30.

Vinassa de Regny P. E., 1896 – *Platycarcinus sismondai* del Museo Parmense e il *Palaeocarpilius macrocheilus* del Museo Pisano. *Rivista Italiana di Paleontologia*, Roma, 2: 124-129.

Vinassa de Regny P. E., 1897 – Contribuzioni alla conoscenza dei crostacei fossili italiani. *Simonellia quiricensis* n. gen. n. sp. del Pliocene di S. Quirico d'Orcia. *Rivista Italiana di Paleontologia*, Roma, 3 (5-6): 19-25.

Wright C. W. & Collins J. S. H., 1972 – British Cretaceou Crabs. *Palaeontological Society Mononograph*, London: 1-114.

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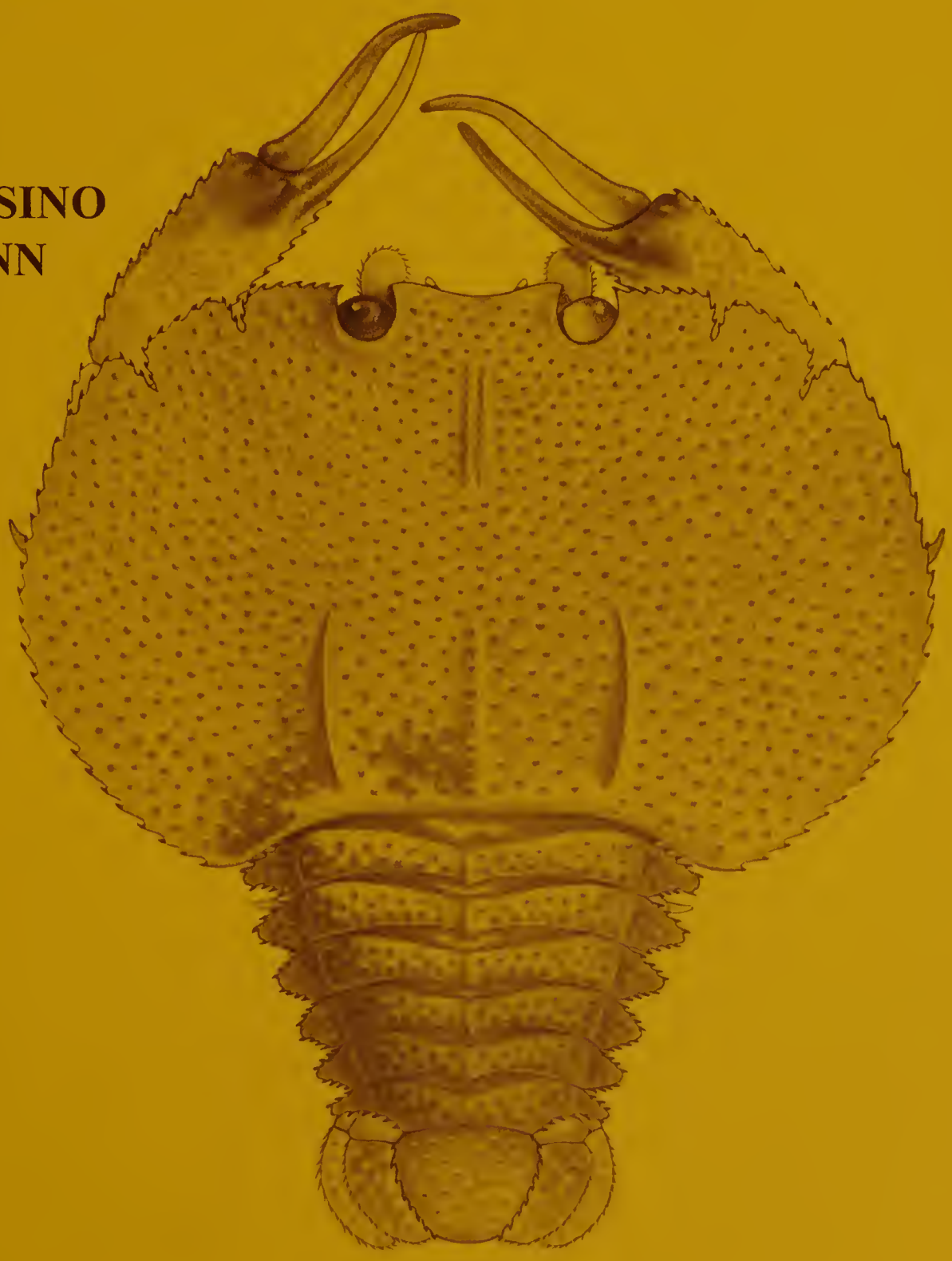

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3rd Symposium
on Mesozoic and Cenozoic Decapod Crustaceans

Museo di Storia Naturale di Milano
May 23-25, 2007

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e del Museo Civico di Storia Naturale di Milano

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In copertina: *Rosenfeldia triasica* Garassino, Teruzzi & Dalla Vecchia, 1996 (reconstruction F. Fogliazza)

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Interest in the paleontological history of the decapod Crustacea has exploded within the past three decades. Perhaps stimulated by the publication, in 1969, of Glaessner's Decapoda in the *Treatise on Invertebrate Paleontology*, the number of people devoted to the study of decapod fossils and the number of published papers on the subject mushroomed. By the beginning of this Century, there had been so many advances in research that the *Treatise* was beginning to show its age, and plans had been laid to produce a revision of that landmark reference. Recognizing that the field had become so vast and that the range of taxa was so great, it was decided to invite experts in different aspects of the study of decapods, from all over the world, to participate in the revision. To launch the effort, the 1st Workshop on Mesozoic and Tertiary Decapod Crustaceans was organized and held in Montecchio Maggiore, Vicenza, Italy. The meeting was attended by over 30 people from all over the world, papers were delivered on a range of subjects from paleoecology, ichnology, systematic paleontology, and theory of classification. Those in attendance included nearly all the most active workers on decapod fossil living at that time. The meeting was wonderful, the response was outstanding, and the enthusiasm for continuing the work on the group was contagious! At the close of the meeting, it was decided to hold another meeting on the subject, and Boxtel, Maastricht, The Netherlands, was selected as the meeting site. That session, held in September, 2003, was attended by essentially the same group of people with the addition of some new students. One of the conclusions reached at that meeting was that the *Treatise* revision was still in progress, but that the volume of research published since the first meeting was so great that much more work needed to be done. I believe it is fair to say that the meeting in Boxtel was as enthusiastically received as was the first and, again, we went away with the plan to continue the tradition of discussing the decapods.

Now, we are at the 3rd Symposium and the excitement about the decapods continues to grow. As one metric, a quick examination of the papers retrievable on the Georef search engine of the American Geological Institute indicates that over 120 papers on fossil decapods have been published since the last meeting in 2003, and that number does not include the majority of papers published within 2006! Examination of some of the titles reveals that these have not been trivial papers - entire families and superfamilies have been revised, large compilations of data on paleobiogeography and been published, and extremely useful catalogues of regional collections and classic faunas are now available. Thus, the work on the Decapoda is proceeding at an unprecedented rate. The attendance at this meeting, based upon pre-registration figures, promises to be as large as the previous meetings, the geographic spread of attendees is as great, and the range of papers published in this volume of extended abstracts is broad and the topics continue to be exciting.

Finally, we all owe a debt of gratitude to Alessandro Garassino for his tireless efforts in making this meeting possible as well as to those who organized the previous two meetings. I am confident that the 3rd Symposium on Mesozoic and Cenozoic Decapod Crustaceans will be a success and that it will be another in a very long series of meetings. Enjoy the abstracts, enjoy the presentations, and perhaps most important, enjoy the company of your colleagues and friends in this wonderful setting.

Rodney M. Feldmann

Shane T. Ahyong & Alessandro Garassino

A new stomatopod from the Upper Cretaceous (Cenomanian) of Lebanon

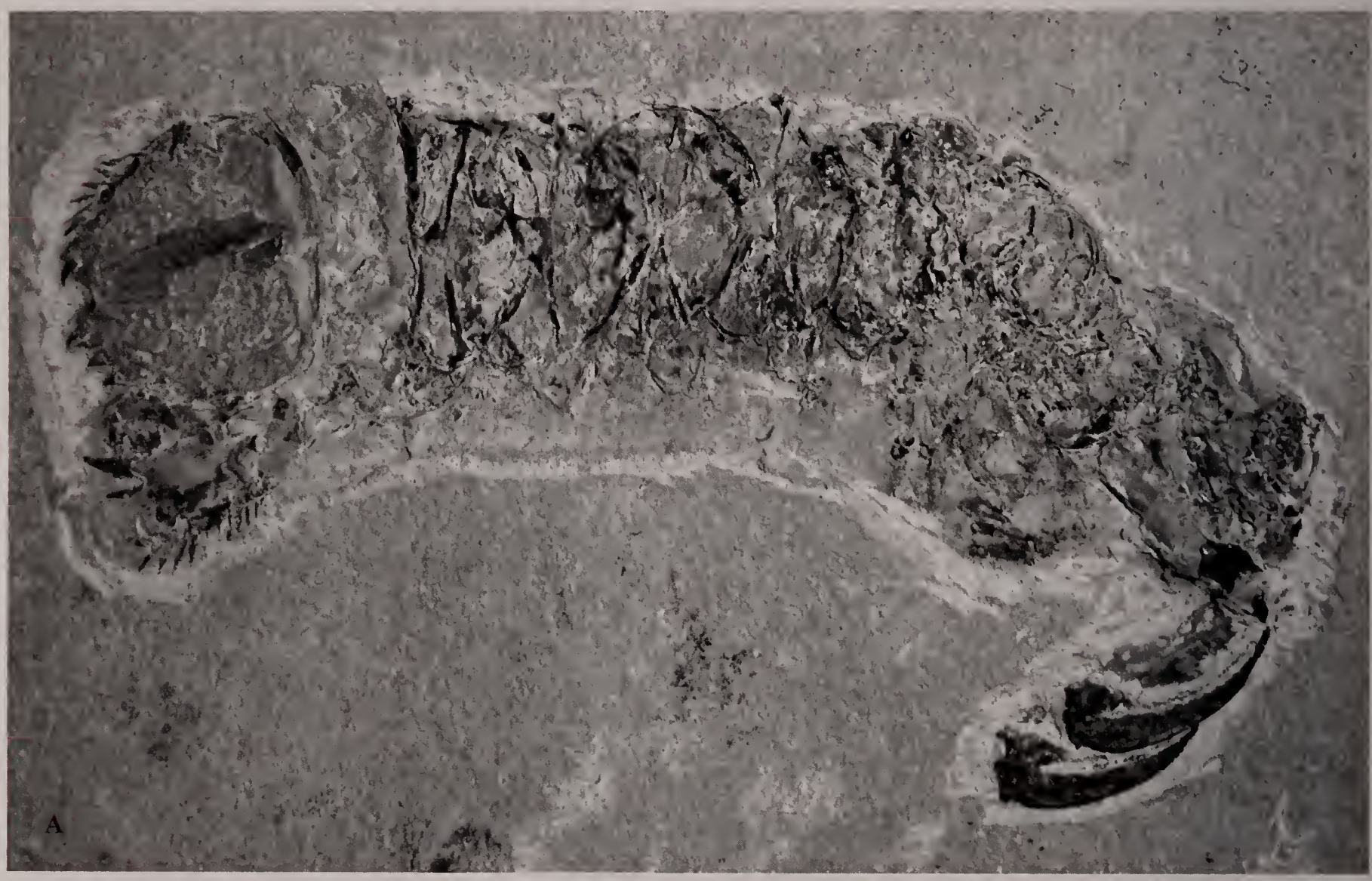
To date, two species of stomatopod are known from the Upper Cretaceous (Cenomanian) of Lebanon: *Pseudosculda laevis* (Schlüter, 1872) (Pseudosculdidae Dames, 1886) and *Sculda syriaca* Dames, 1886 (Sculdidae Dames, 1886), studied by Schlüter (1872, 1874), Woodward (1879), Dames (1886), Roger (1946), and Teruzzi (1983). Sculdidae and Pseudosculdidae, with a Jurassic–Cretaceous and Upper Cretaceous range, respectively, are believed to represent stem-lineage unipeltatans (see Hof, 1998; Ahyong & Harling, 2000). An unusual fossil stomatopod was discovered in the sedimentary layers of Haqel quarry (northeastern Lebanon), of lower–middle Cenomanian age (Upper Cretaceous) (Hückel 1970, 1974a, 1974b). Haqel, located about 12 km from the Mediterranean coast and 45 km from Beirut, is one of the richest fossil sites in Lebanon, yielding numerous vertebrate and invertebrate fossils, including Crustacea (e.g. Dames, 1886; Glaessner, 1945; Roger, 1946; Garassino, 1994, 2001; Larghi, 2004; Garassino & Schweigert, 2006).

Ahyong *et al.* (2007) described *Archaeosculda phoenicia*, the second known genus and species of Pseudosculdidae. It has a subovate telson and is slightly broader than long, with a distinct median carina and four pairs of primary marginal teeth of which the submedians have movable apices, and a broad, subovate uropodal endopod. This species is unique in the Pseudosculdidae by exhibiting a broad telson with three pairs of prominent, fixed primary teeth (in addition to the moveable submedian teeth) and a broad, ovate, uropodal endopod. In contrast, the only other recognised pseudosculdid, *Pseudosculda laevis*, bears an elongate, triangular telson with small primary teeth that do not project much beyond the general telson outline, and a slender, elongate, uropodal endopod. Moreover, at 75 mm total length, *A. phoenicia* apparently reaches a larger size than *P. laevis*, known to reach only 55 mm total length (Holthuis & Manning, 1969). The dissimilarities between the telson of *Archaeosculda* and *Pseudosculda* are marked, but the four pairs of primary teeth can probably be homologized between the two genera. Homologizing the telson teeth of pseudosculdids and those of crown-group unipeltatans is more complicated, and requires further research.

Feldmann *et al.* (1999) reported a fragmentary fossil stomatopod from Cretaceous of Colombia that was tentatively assigned to *Sculda* on the basis of telson morphology whereby the length and width are approximately equal and the posterior margin is lined with long, moveable spines, a distinctive feature of Sculdidae. Schram & Müller (2004), however, reassigned the Colombian specimen to *Pseudosculda* on the basis of the raptorial claw. The dactyli of the raptorial claws of the Colombian specimen resemble those of pseudosculdids, but it is noteworthy that the raptorial claws of *Sculda* are presently unknown. The Colombian specimen is certainly not *Pseudosculda*, and it is doubtful that it belongs to Pseudosculdidae either.

Cladistic analyses of the Stomatopoda have recognised Sculdidae and Pseudosculdidae as stem-lineage unipeltatans, with the pseudosculdids as sister to crown-group Unipeltata (see Hof, 1998; Ahyong & Harling, 2000). The chief character excluding sculdids and pseudosculdids from the crown-group is the plesiomorphic uropodal exopod segmentation, being unisegmental rather than bi-segmental. Sculdidae, as presently composed, can be diagnosed by several apomorphies such as the broad, dorsoventrally depressed body, the absence of a median carina on the telson, and most importantly, the posterior telson margin lined with moveable spines. Unfortunately, the raptorial claws of sculdids, being unknown, cannot be compared to those of pseudosculdids. Pseudosculdidae is distinguished from Sculdidae by the narrower, more subcylindrical body form, and the median carina on the telson. Only the submedian primary telson teeth are articulated. Hof (1998) and Schram & Müller (2004) regarded the well-sclerotized scythe-like dactylus of the raptorial claw as a defining feature of Pseudosculdidae. The raptorial claws of members of the crown-group Hemisquillidae Manning, 1980 (superfamily Gonodactyloidea), however, are structurally similar to pseudosculdids, albeit with proportionally shorter dactyli and propodi. The differences between the raptorial claws of hemisquillids and pseudosquillids are essentially morphometric, so care should be taken to avoid placing undue emphasis on the raptorial claws in defining and assigning taxa to Pseudosculdidae. Note also that *Hemisquilla* Hansen, 1895, is basal in the Gonodactyloidea (Ahyong & Harling, 2000), so its raptorial claw morphology perhaps reflects the stem-lineage condition. Other recognized characters of Pseudosculdidae are not unique - the subcylindrical body is a plesiomorphy inherited from archaeostomatopodeans and retained by the modern gonodactyloids and parasquilloids; and the telson with a distinct median carina and moveable submedian telson teeth is retained by almost all modern unipeltatans. Consequently, no robust synapomorphies are presently known that unite *Pseudosculda* and *Archaeosculda* raising the possibility that Pseudosculdidae is paraphyletic. To be sure, the anterior cephalic appendages of *Pseudosculda* and *Archaeosculda* are incompletely known and more complete fossils may reveal synapomorphies. Nevertheless, the discovery of *Archaeosculda phoenicia* is significant, not only for expanding the rare Mesozoic stomatopod fossil record, but also in increasing knowledge of the morphospace occupied by stem-lineage unipeltatans.

At present, sculdids are known reliably from the Upper Jurassic to Middle Cretaceous and the pseudosculdids from the Upper Cretaceous. Pinna (1985) listed two ill-preserved stomatopod fossils from the Lower Jurassic (Sinemurian) of Osteno in northern Italy, representing the oldest known unipeltatans. Hof (1998) indicated that the Osteno specimens represent an undescribed *Pseudosculda*-like species. If the Osteno specimens are pseudosculdids, and if current phylogenetic hypotheses are correct, then both the Pseudosculdidae and Sculdidae are considerably older than presently recognized.



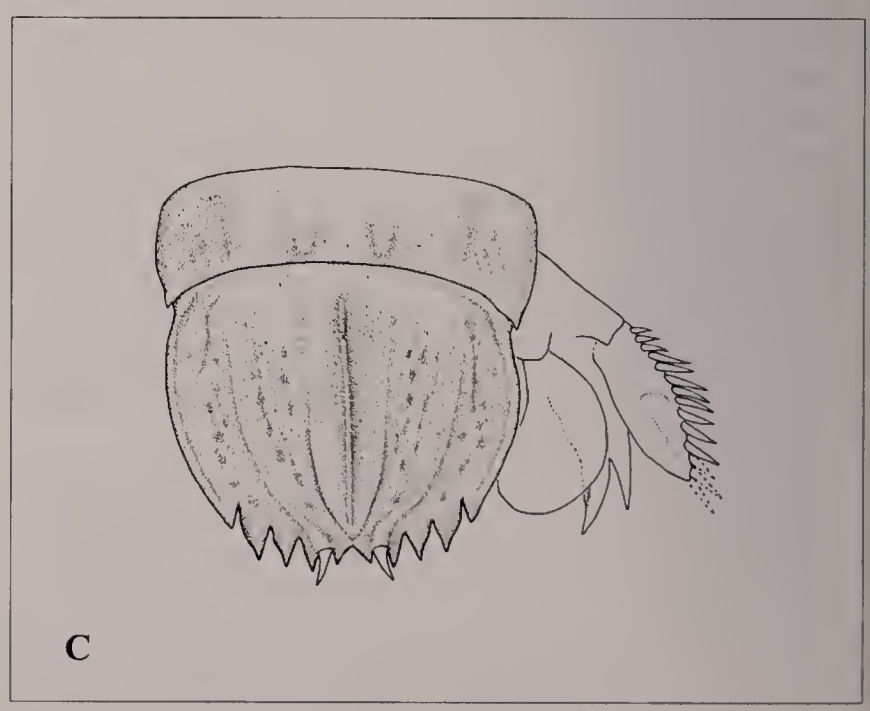


Fig. 1 – A) *A. phoenicia* Ahyong, Garassino & Gironi, 2007, dorso-lateral view. B) *A. phoenicia* Ahyong, Garassino & Gironi, 2007, tail fan. C) Recostruction of the tail fan.

References

Ahyong S. T. & Harling C., 2000 – The phylogeny of the stomatopod Crustacea. *Australian Journal of Zoology*, 48 (6): 607-642.

Ahyong S. T., Garassino A. & Gironi B., 2007 – *Archaeosculda phoenicia* n. gen., n. sp. (Crustacea, Stomatopoda, Pseudosculdidae) from the Upper Cretaceous (Cenomanian) of Lebanon. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 148 (1): 3-15.

Dames W., 1886 – Ueber einige Crustaceen aus den Kreidablagerunden des Libanon. *Zeitschrift der Deutschen Geologischen Gesellschaft*, Berlin, 38: 551-575.

Feldmann R. M., Villamil T. & Kauffman E. G., 1999 – Decapod and stomatopod crustaceans from mass mortality Lagerstatten: Turonian (Cretaceous) of Colombia. *Journal of Paleontology*, Lawrence, 73: 91-101.

Garassino A., 1994 – The macruran decapod crustaceans of the Upper Cretaceous of Lebanon. *Paleontologia Lombarda*, Nuova serie, Milano, 3: 3-27.

Garassino A., 2001 – New decapod crustaceans from the Cenomanian (Upper Cretaceous) of Lebanon. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 141 (2): 237-250.

Garassino A. & Schweigert G., 2006 – *Cretasergestes sahelalmaensis* n. gen., n. sp. (Crustacea, Decapoda, Sergestidae) and *Cancrinos libanensis* n. sp. (Crustacea, Decapoda, Palinuridae) from the Late Cretaceous (Cenomanian) of Lebanon. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (1): 69-78.

Glaessner M. F., 1945 – Cretaceous Crustacea from Mount Lebanon, Syria. *Annals and Magazine of Natural History Museum*, London, 12 (11): 694-707.

Hof C. H. J., 1998 – Fossil stomatopods (Crustacea: Malacostraca) and their phylogenetic impact. *Journal of Natural History*, 32: 1567-1576.

Holthuis L. B. & Manning R. B., 1969 – Stomatopoda. In: Treatise on Invertebrate Paleontology. Arthropoda. Moore R. C. (ed.). *Geological Society of America and University of Kansas*, Lawrence, 4 (2): R535-552.

Hückel U., 1970 – Die Fischschiefer von Hakel und Hjoula in der Oberkreide des Libanon. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, Stuttgart, 135 (2): 113-149.

Hückel U., 1974a – Vergleich des Mineralbestandes der Plattenkalke Solnhofens und des Libanon mit anderen Kalken. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, Stuttgart, 145 (2): 153-182.

Hückel U., 1974b – Geochemischer Vergleich der Plattenkalke Solnhofens und des Libanon mit anderen Kalken. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, Stuttgart, 145 (3): 279-305.

Larghi C., 2004 – Brachyuran decapod crustaceans from the Cenomanian (Upper Cretaceous) of Lebanon. *Journal of Paleontology*, Lawrence, 78 (3): 528-541.

Pinna G., 1985 – Exceptional preservation in the Jurassic of Osteno. *Philosophical Transactions of the Royal Society of London*, London, B 311: 171-180.

Roger J., 1946 – Les invertébrés des couches a poissons du Crétacé supérieur du Liban. *Mémoires de la Société Géologique de France*, Paris, 23: 1-92.

Schlüter C., 1872 – Ueber einen fossilen Stomatopoden von Libanon. *Sitzungberichte Naturistorischen Verein der Preussischen Rheinlande und Westfalens*, Bonn, 29: 194-195.

Schlüter C., 1874 – Ueber einige jurassische Crustaceen-Typen in der oberen Kreide. 1. Fossile Krebse des Libanon. *Sitzungberichte Naturistorischen Verein der Preussischen Rheinlande und Westfalens*, Bonn, 31: 41-55.

Schram F. R. & Müller H.-G., 2004 – Catalog and bibliography of the Fossil and Recent Stomatopoda. *Backhuys publishers*, Leiden, The Netherlands.

Teruzzi G., 1983 – Un nuovo esemplare di *Palaeosculda laevis* (Schlüter, 1872) del Cenomaniano di Hakel nel Libano. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 124 (1-2): 117-122.

Woodward H., 1879 – Contributions to the knoweledge of fossil Crustacea. *Quarterly Journal of the Geological Society*, London, 35: 549-556.

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Pedro Artal & Alonso Gilles

New Miocene crabs from Pignan (southeast France)

Marine sediments from the Château Saint-Martin quarry, still active, situated close to the village of Pignan, and not far from Montpellier (Herault, southeast France), have yielded a very rich crustacean fauna during the last five years. The outcrops are frequently removed by mining, and are nearly at the point of disappearing. We have recorded a decapod association characteristic for the Mediterranean area. Miocene strata around Montpellier has been studied from the XIX century (see Roman, 1897), and were first mentioned in terms of remains of fishes, mainly shark teeth, and sporadic crabs of large size. The upper sediments from the area, the subject of this note, are about 20 m thick, and consist of bioclastic carbonates with embedded pockets of laminated clayey silts containing some fossil plants. The silt pockets are 3 m thick and about 10 m long. The underlaying beds, composed of sands, conglomerates of small size, and marls, yielded an abundant and diverse fish fauna. This fauna completely corresponds to the fauna of selachians described by Capetta (1970), which were collected from sediments of Helvetian and Burdigalian age in the Herault. The authors of the geological map of Montpellier mention of the Pignan quarry and the bioclastic layers as being upper Burdigalian in age. The shell calcarenites dominated by moulds of gastropods, bivalves, some bryozoans, and worms provided very few crabs, except for some small calappids and leucosids. Most crabs were collected in the clayey and sandy silt pockets, being better preserved according to the grain size. In the basal beds rich in fish remains *Necronectes* sp. and *Portunus monspeliensis* (A. Milne Edwards, 1860) of major dimensions occur.

The decapod assemblage contained in the clay mainly consists of isolated carapaces of average to small size, from a few milimeters to five centimeters. Corpses are extremely rare, except for some portunids and goneplacids. All the assemblage has been tentatively assigned to 13 families and 16 genera. The most frequent, in number of specimens, are portunids, calappids, leucosids, dorippids, and majids. Some other genera are only represented by a unique fossil, very few specimens, or badly preserved remains.

Portunids, the most common and diverse decapods, tentatively include the genera *Portunus* Weber, 1795, *Liocarcinus* Stimpson, 1871, and *Necronectes* A. Milne Edwards, 1881. They tend to be small size. The family Calappidae H. Milne Edwards, 1837, appears to be very abundant, with very well preserved small carapaces of the genus *Calappa* Weber, 1795. The family Dorippidae MacLeay, 1838, is well represented in number of specimens of the genus *Ethusa* Roux, 1830, rather constant, and probably the genus *Medorippe* Manning & Holthius, 1981. Leucosiids are also common and rather well preserved, the family Leucosiidae Samouelle, 1819, is documented by the genus *Ebalia* Leach, 1817; distinctive isolated female abdomina also occur. The family Majidae Samouelle, 1819, is represented by only one genus, frequent in number despite the shell not being well preserved. The goneplacids, very common in European Miocene strata are also present; in this case the family Goneplacidae Mac Leay, 1838, can be documented with confidence through the genus *Goneplax* Leach, 1814. Xanthoids belonging to the families Panopeidae Ortmann, 1893, and Menippidae Ortmann, 1893, are confirmed by well preserved material of the genera *Panopeus* H. Milne Edwards, 1834, and *Eriphia* Latreille, 1817. Dromiids and cancroids are rare but certain; the genus *Atelecyclus* Leach, 1814, is confirmed by a unique specimen of unusually small size. Some homolids and possible pirimelids also seem to be present, but better specimens are needed for confirmation. The absence of isolated claws, and the absence of anomurans is remarkable. Fingers and more or less complete palms are hard parts considered to be easily preserved. Only a large finger of a possible pagurid has been recorded to date. The decapod association, the assemblage of molluscs, and the terrigenous sediments containing fossil leaves, suggest a littoral environment. The fossil plants are similar to the genus *Avicennia*, which suggests the possible proximity of a mangrove.

Miocene crab faunas are not well represented in the south of Europe, except for the rich Badenian of Hungary (Müller, 1984) and less diverse, but also abundant, from Catalonia (Müller, 1993; Solé & Via, 1988). Miocene decapods from Italy consist of small assemblages of few genera (De Angeli & Marangon, 1992; De Angeli & Garassino, 2006). The new French decapod association cannot be completely related to the former assemblages, probably due to the provenance from different environments, but it does share some genera with the faunas from Italy, Spain, and Hungary. In Catalonia, the nearest area with similar Miocene layers, *Portunus monspeliensis* is also common, but occurs occasionally associated with other decapods or in less diverse assemblages. The frequent *Macrophthalmus aquensis* A. Milne Edwards & Brocchi, 1879 (see Müller, 1993) is not present in Pignan. The entire new assemblage from the southeast of France, at the level of genera, seems to be confirmed as strongly related to the recent Mediterranean fauna (Zariquiey, 1968). Further studies and possible new material improving our understanding of the poorly preserved genera will permit increasing our knowledge of the Mediterranean-Thetyan realm.

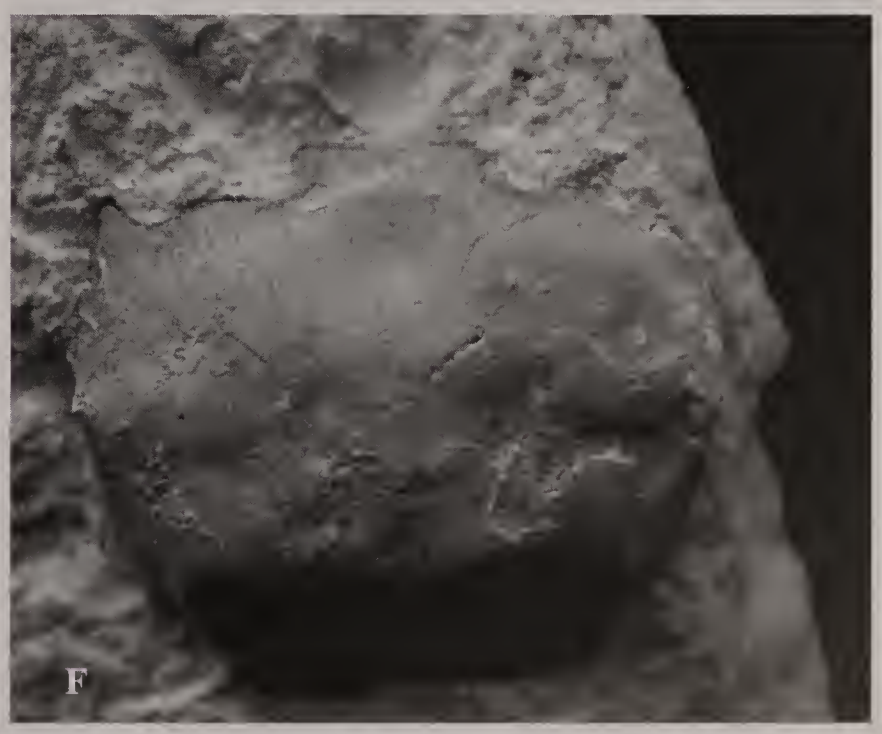

Fig. 1 – A) *Necronectes* cf. *schafferi*. B) *Liocarcinus* sp. C) *Portunus monspeliensis*, ventral view. D) *Necronectes* sp. E) *Eriphia* sp. F) *Goneplax* sp.

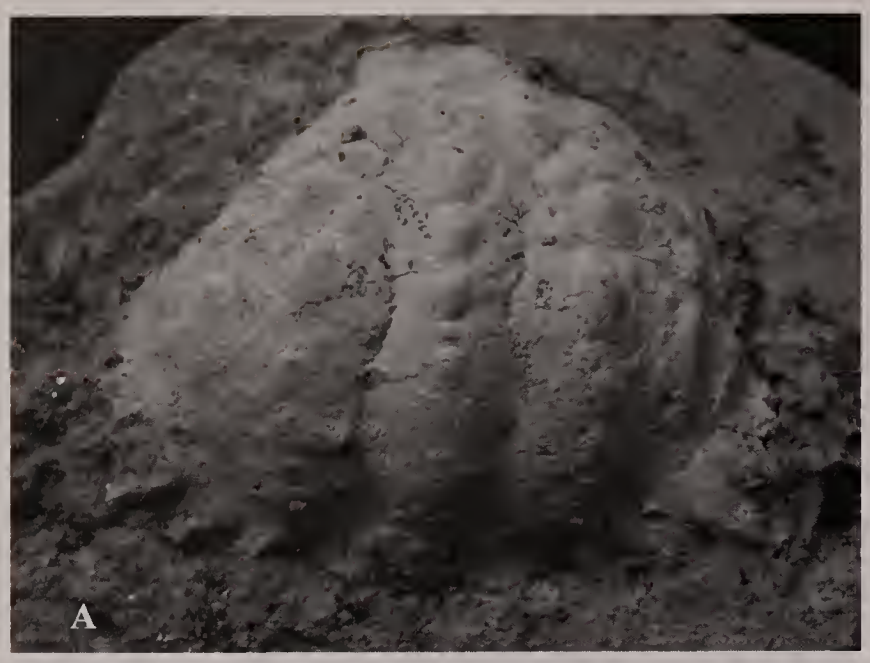

Fig. 2 – A) *Calappa* sp. B) *Ebalia* sp., dorsal view. C) *Ebalia* sp., abdomen. D) *Panopeus* sp. E) Majidae sp. F) *Ethusa* sp.

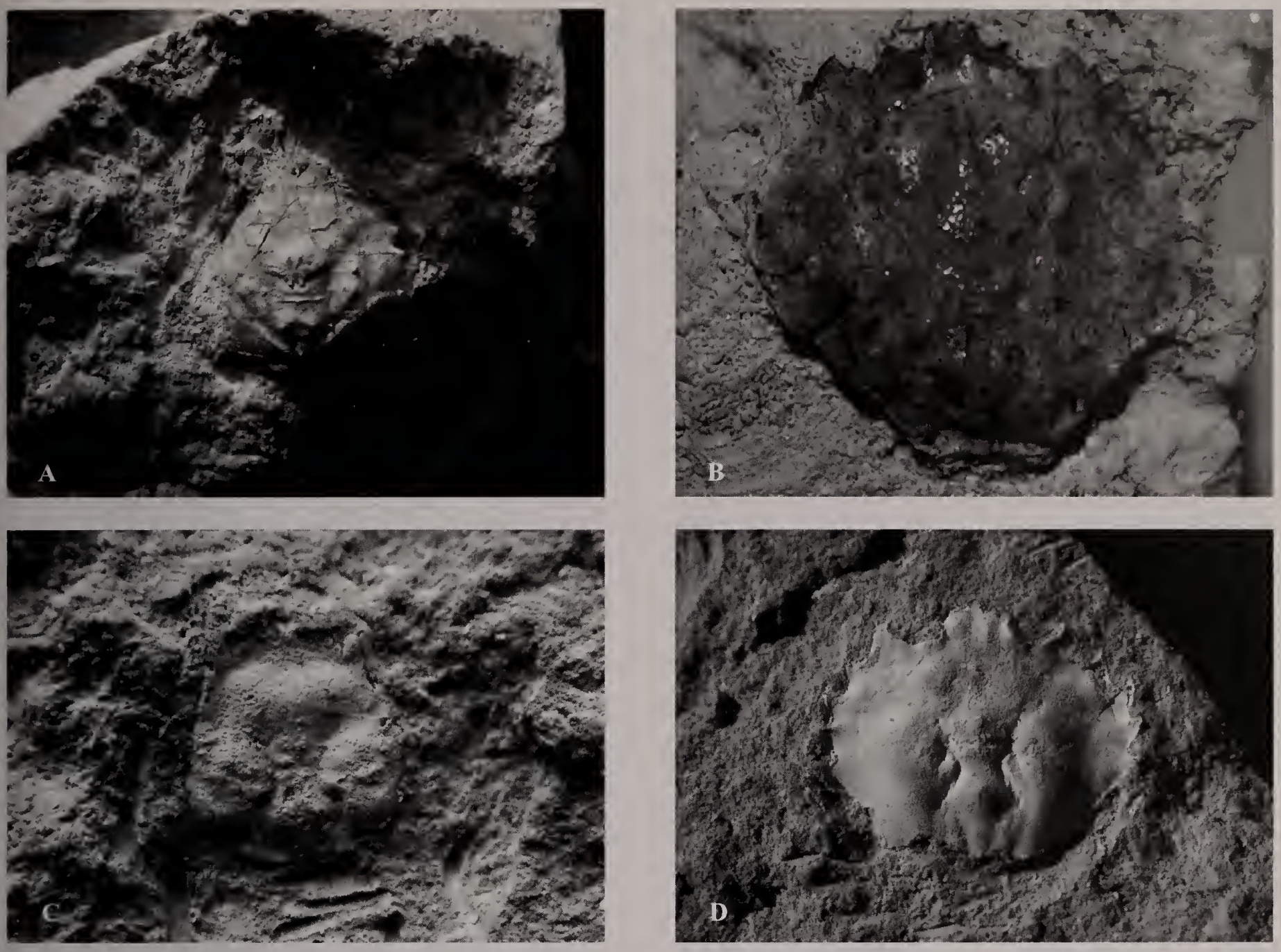

Fig. 3 – A) Dromiidae sp. B) *Atelecyclus* sp. C) Dorippidae sp. D) Portunidae sp.

References

Capetta H., 1970 – Les sélaciens du Miocène de la région de Montpellllier. *Palaeovertebrata mém. ext.*, Montpellier: 1-139.

De Angeli A. & Garassino A., 2006 – Catalog and bibliography of the fossil Stomatopoda and Decapoda from Italy. *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 35 (1): 1-95.

De Angeli A. & Marangon S., 1992 – *Necronectes schafferi* Glaessner, nel Miocene della Sardegna (Italia). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 17: 175-182.

Milne Edwards A., 1881 – Notes sur quelques crustacés fossiles des environs de Biarritz. *Annales des Sciences Geologiques*, 11 (2): 1-8.

Müller P., 1984 – Decapod Crustacea of the Badenian. *Geologica Hungarica, Serie Palaeontologica*, 42: 1-121.

Müller P., 1993 – Neogene decapod crustaceans from Catalonia. *Scripta Musei Geologici Seminarii Barcinonensis*, Barcelona, 225: 1-39.

Roman F., 1897 – Recherches stratigraphiques et paléontologiques dans le Bas-Languedoc. *Annales Université Lyon*, Lyon: 1-345.

Solé J & Via L., 1988 – Crustacis Dècapodes fòssils dels Països Catalans (Recopilació i actualització de dades de 1855 a 1988). *Batalleria*, Barcelona, 2: 23-42.

Zariquiey Alvarez R., 1968 – Crustáceos Decápodos Ibéricos. *Investigaciones Pesqueras,* Barcelona, 32: 1-510.

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Claudio Beschin, Alessandra Busulini & Giuliano Tessier

First report of a new Eocene crustacean fauna from the Veronese Lessini (N Italy)

Parona is a little village located near the western boundary of the Verona commune, in the last part of the Negrar Valley (Fig. 1). Here an interesting fossil crustacean fauna has been found in the Priabonian levels that now are no more accessible because of intense urbanization.

From a morphological point of view, this area is characterized by a series of low hilly digitations directed N-S stretching out toward the Po River and Veneto plain. The plain is here made of the detrital materials carried by Adige River that flows in meanders near the slopes of the same low hills.

The Parona stratigraphic series is Eocene in age; it is comprised of bedded carbonate deposits (Nummulite Limestones of middle Eocene), on which is overlain grey-greenish and/or yellowish marls without clear stratification and full of discocyclinids (Priabona Marls of upper Eocene). On the ground, the limits of these two units are very apparent above all by the presence on the upper part of the series of the Priabonian clayey lithotypes.

From a palaeontological point of view in the studied Priabonian formation, larger foraminifera and bivalves (particularly ostreids), but also coralline algae, bryozoans, gastropods, echinids, and crustaceans have been found. The fossil association indicates a nerithic shallow marine environment probably not far from the coast and affected by significant terrigenous supplies (De Zanche *et al.*, 1977).

The analysis of the fossil crustaceans found here and now deposited in the Museo Civico "G. Zannato" at Montecchio Maggiore (Vicenza), allowed identification of about ten species of Brachyura; the remains consist of carapaces and some propoda of chelipeds. Their preservation is not good; the original shell is often altered and appears dusty.

Even when the number of specimens is moderate, the fauna is differentiated: the following genera have been identified within seven families: Dromiidae de Haan, 1833; *Noetlingia* Beurlen, 1928: Dynomenidae Ortmann, 1892; *Kromtitis* Müller, 1984: Raninidae de Haan, 1841; *Lophoranina* Fabiani, 1910: Calappidae de Haan, 1833; *Calappilia* A. Milne Edwards, 1873: Parthenopidae MacLeay, 1838; "*Phrynolambrus*" Bittner, 1893: Pilumnidae Samouelle1819; *Eohalimede* Blow & Manning, 1996; *Lobonotus* A. Milne Edwards, 1864: Panopeidae Ortmann, 1893; *Palaeograpsus* Bittner, 1875.

Fig. 1 – General location of the Parona village.

In this fossil association both species with burial habit such as *Lophoranina laevifrons* (Bittner, 1875) and species typical of reefal environment such as *Kromtitis* sp. are present; this makes one presume that probably some specimens were carried to the deposition basin from the surrounding areas.

The discovery of *Noetlingia veronensis* (Bittner, 1886) that, after the publication of the initial work on the species, had never been reported again and of "*Phrynolambrus*" *corallinus* Bittner, 1893 reported for the first time in the Italian territory is remarkable.

The largest number of specimens discovered in this deposit are representative of two species: *Calappilia dacica* Bittner, 1893 and *Kromtitis* sp.

Calappilia dacica, formerly found in upper Eocene levels in Hungary (Bittner, 1893, Lörenthey & Beurlen, 1929), had already been reported in "Main" quarry at Arzignano (Vicenza) (Busulini *et al.*, 1982); the specimens found at Parona show the spines on the posterolateral margins to be smaller than those described by Bittner; this peculiarity could be caused by different preservation. In the Eocene of Veneto, other species within the same genus have been found: *C. gemmata* Beschin, Busulini, De Angeli & Tessier, 1994; *C. incisa* Bittner, 1886; and *C. subovata* Beschin, Busulini, De Angeli & Tessier, 2002.

The genus *Kromtitis* Müller, 1984, also has previously been recognized in Veneto: *K. tetratuberculatus* Beschin, Busulini, De Angeli & Tessier, 2002, was found in "Main" quarry at Arzignano while the analysis of the fossil fauna discovered at Gecchelina, even though not complete, highlights more than one species within the same genus (Beschin *et al.*, 2000); the Parona form differs from all these and probably is a new species; such variety suggests a suitable environment and rapid evolution of this group.

The discovery of *Lobonotus* cf. *L. sandersi* is particularly relevant: this species has been previously described from the Eocene of south Carolina within the genus *Eohalimede* (Blow & Manning, 1997) and subsequently attributed to *Lobonotus* (Schweitzer *et al.*, 2002): its presence in northern Italy confirms the well-known analogies between these American faunas and those coeval ones in Veneto (Feldmann *et al.*, 1998, Beschin *et al.*, 2002); if the generic attribution should be confirmed the hypothesis that the geographic distribution of the genus *Lobonotus* is limited to the Americas will have to be reconsidered.

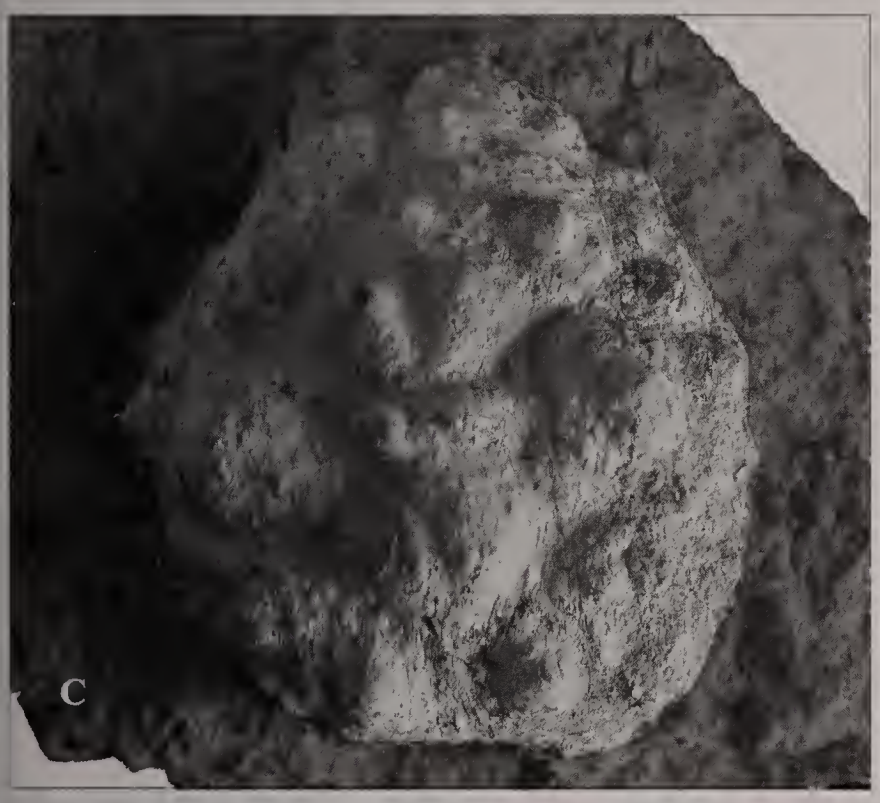

Fig. 2 – A) *Calappilia dacica* Bittner, 1893 - MCZ 1342. B) *Noetlingia veronensis* (Bittner, 1886) - MCZ 1343. C) *Kromtitis* sp. - MCZ 1346. D) "*Phrynolambrus" corallinus* Bittner, 1893 - MCZ 1345. E) *Lobonotus* cf. *L. sandersi* - MCZ 1344. F) *Palaeograpsus inflatus* Bittner, 1875 - MCZ 2522.

References

Beschin C., Busulini A., De Angeli A. & Tessier G., 1994 – I Crostacei eocenici della cava "Boschetto" di Nogarole Vicentino (Vicenza - Italia Settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 19: 159-215.

Beschin C., Busulini A., De Angeli A. & Tessier G., 2002 – Aggiornamento ai crostacei eocenici di cava "Main" di Arzignano (Vicenza - Italia settentrionale) (Crustacea, Decapoda). *Studi e ricerche - Associazione Amici del Museo - Museo civico "G. Zannato"*, Montecchio Maggiore (Vicenza): 7-28.

Beschin C., Busulini A., De Angeli A., Tessier G. & Ungaro S., 2000 – The fauna of the Gecchelina quarry at Monte di Malo (Vicenza - Northern Italy): a preliminary study. *"1st Workshop on Mesozoic and Tertiary decapod crustaceans", Studi e ricerche - Associazione Amici del Museo - Museo civico "G. Zannato"*, Montecchio Maggiore (Vicenza): 7-10.

Bittner A., 1886 – Neue Brachuyren des Eocäns von Verona. *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien*, Wien, 94 (I): 44-55.

Bittner A., 1893 – Decapoden des pannonischen Tertiärs. *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien*, Wien, 102 (II): 10-37.

Blow W. C. & Manning R. B., 1996 – Preliminary descriptions of 25 new decapod crustaceans from the middle Eocene of the Carolinas, U.S.A. *Tulane Studies in Geology and Paleontology*, New Orleans, 26 (1): 1-26.

Blow W. C. & Manning R. B., 1997 – A new genus, *Martinetta*, and two new species of xanthoid crabs from the Middle Eocene Santee Limestone of South Carolina. *Tulane Studies in Geology and Paleontology*, New Orleans, 30: 171-180.

Busulini A., Tessier G. & Visentin M., 1982 – Brachyura della Cava Main (Arzignano) - Lessini orientali (Vicenza) (Crustacea, Decapoda). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 7: 75-84.

De Zanche V., Sorbini L. & Spagna V., 1977 – Geologia del territorio del Comune di Verona. *Memorie del Museo Civico di Storia Naturale, II serie*, Verona, 1: 1-51.

Feldmann R. M., Bice K. L., Hopkins C. S., Salva E. W. & Pickford K., 1998 – Decapod crustaceans from the Eocene Castle Hayne Limestone, North Carolina: paleoceanographic implications. *The Paleontological Society, Memoir 48, Supplement to Journal of Paleontology*, Lawrence, 72 (1): 1-28.

Lörenthey I. & Beurlen K., 1929 – Die fossilen Decapoden der Länder der Ungarischen Krone. *Geologica Hungarica, Serie Paleontologica,* Budapest, 3: 1-420.

Schweitzer C. E., Feldmann R. M., Gonzáles-Barba G. & Vega F. J., 2002 – New crabs from the Eocene and Oligocene of Baja California Sur, Mexico and an assessment of the evolutionary and paleobiogeographic implications of Mexican fossil decapods. *The Paleontological Society, Memoir 59, Supplement to Journal of Paleontology*, Lawrence, 76 (6): 1-43.

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Gale A. Bishop

Mechanism for phosphatization of *Dakoticancer* assemblages in the Late Cretaceous western interior Seaway, USA

Fossil decapod crustaceans have often been described as minor elements of molluscan assemblages and occasionally been described from decapod-dominated assemblages preserved as lagerstätte. Because of their normal scarcity in the fossil record it is essential that maximal information be consistently presented by authors that will allow future workers to place the decapod taxa into their historical, evolutionary, ecological, and systematic context. This has often been done by describing the overall aspects of a fauna; including its geographic, geologic, and stratigraphic context.

Because of their complex exoskeleton, fossil decapods are often incomplete and preserved as disassociation units (Bishop, 1986; Bishop & Williams, 1986, 2005) that normally disassociate as decomposition proceeds. Disassociation units typically consist of structural units of the exoskeleton, carapace, sternum, abdomen, and chelipeds or pereiopods. Completeness of specimens varies from assemblage to assemblage and depends upon the physical, biological, and chemical conditions of the burial site and diagenetic changes.

Lagerstätten are fossil assemblages that are remarkable in either their diversity or quality of preservation, usually both. The *Dakoticancer* Assemblages in the Pierre Shale of south Dakota are largely represented by lagerstätten (Fig. 1) whose structure and formative process have been described, but whose formative genesis remained unknown. The scenario envisioned (Bishop, 1981, 1986, 1987; Bishop & Williams 1986, 2005; Bishop *et al.*, 1998) involved periodic volcanic events that killed the phytoplankton and zooplankton in the Cretaceous western interior Seaway. The volcanic ejecta that rained onto the bottom enriching its nutrient load, which was then exploited by a population explosion of segmented worms which pelletized the sediment, concentrating phosphate in the fecal pellets. This setting was than exploited by a population explosion in decapods, which died and were burrowed and pelleted by the worms. The decapods remains were *somehow* phosphatized by chemical reactions in the sediment around the buried decapods lying in the bentonitic substrate.

It is hypothesized herein that the preservation of these lagerstätte is due to the presence in the substrate of a sulfur and phosphate mediating bacterium related to *Thioploca, Beggiatoa*, or *Thiomargarita*. Filamentous, nitrate-accumulating sulfur bacteria described in 1907 of the genus *Thioploca* Lauterborn, 1907, form extensive populations of up to 120 g wet weight/m^2 along the coast of Chile and Peru (1–3). *Thiomargarita namibiensis* described (Schultz *et al.*, 1999), from the Namibian coast, is a colossal bacterium (nearly a millimeter in diameter). Schulz & Schulz (2005: 416) demonstrated that it accumulates intracellular polyphosphates under aerobic conditions and releases phosphate under anoxic conditions. These effects were measured into the substrate with a maximum concentration at approximately 3 cm beneath the water/sediment interface. This process creates pore water supersaturated in phosphate that precipitates as phosphorite. The release of phosphate by these organisms explains the accumulation of many phosphorites in the geological record, including those preserving the *Dakoticancer* Assemblages. "Although *Thiomargarita* appear to thrive best under low oxygen or anoxic conditions, exposure to atmospheric oxygen levels were not toxic as has been observed for *Beggiatoa* (Nelson *et al.*, 1986) and *Thioploca* (Maier & Gallardo, 1984)".

Decapod assemblages described from north America (Bishop, 1981, 1986, 1987; Bishop & Williams 1986; Bishop *et al.*, 1998) are decapod-dominated assemblages overprinted on molluscan background assemblages. The decapod assemblages from the western interior are characterized by: 1) being dominated by decapod crustaceans numbering in the thousands; 2) consisting of 1-3 dominant taxa with 6-7 sub-dominant decapod taxa and numerous non-decapod taxa; 3) being widespread over areas from a few hundred to up to 1500 sq. km with discrete boundaries; 4) being confined to 1-3 m of bentonitic shale, but not in discrete concentration layers; 5) being preserved in phosphatic concretions exhibiting abundant burrows and fecal pellets ascribable to segmented worms; 6) being beautifully preserved, articulated decapods, often with cuticle intact.

These assemblages have been interpreted (Bishop, 1981, 1986, 1987; Bishop & Williams 1986; Bishop *et al.*, 1998) as positive feedback systems involving volcanic ash falls, which killed (directly or indirectly) the phyto- and zooplankton causing an enriching nutrient fall onto the shallow sea bottom. This initiated an explosion of population growth in annelid worms and triggered a population explosion of ubiquitous decapods in the area affected by and amenable to such population increases. The burgeoning populations would continue to support themselves over an interval of time, but would slowly decline and tail off.

A thin-section of a phosphatic concretion containing a transverse cross section of *Dakoticancer overanus* (Fig. 2) shows carapace and pereiopods surrounded and filled by burrowed and pelleted (muddy) sediment. Between and around the pellets and burrows is a diffuse field of small crystallites. Comparison with data presented by Schultz & Schultz, (2005; Fig. 3), shows similar crystallites of phosphate within the cells of *Thiomargarita*, surrounded by vacuoles containing sulfur. The high concentration of

phosphate in sediment 3 cm beneath the surface (Schultz & Schultz, 2005), the presence of phosphatic crystallites, and the burrowing by worms indicating shallow burial in the substrate are all consistent with the proposed feedback scenario of Bishop (1981, 1986, 1987) and Bishop & Williams (1986).

It is suggested that sulphur and phosphate mediating bacteria similar to *Thiomargarita*, if not ancestral to it, were intimately involved in generating the phosphate necessary to form the concretions preserving the phosphatic *Dakoticancer* lagerstätten of south Dakota.

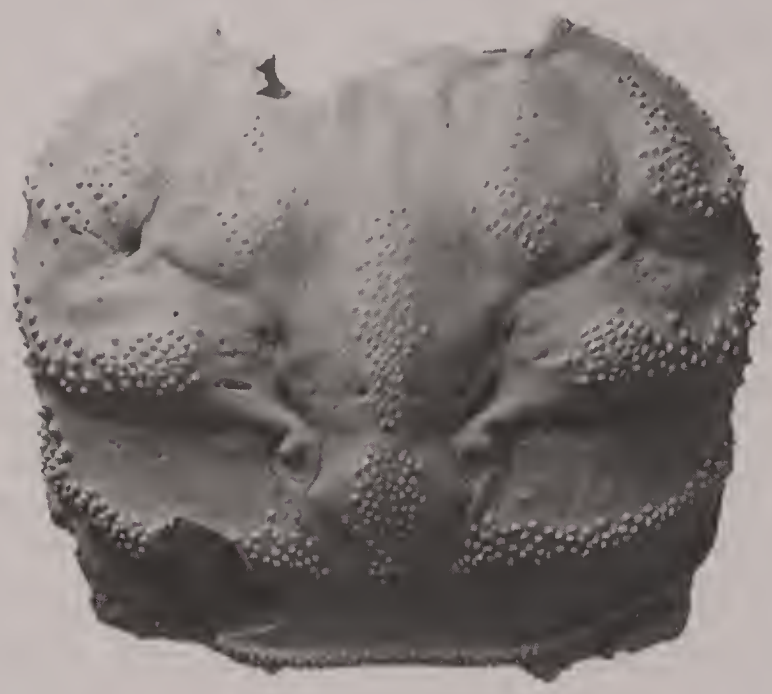

Fig. 1 - The crabs of the *Dakoticancer* Lagerstätten exhibit phenomenal preservation, preserving significant portions of specimens, including eye stalks, cuticle, and setal pits. Specimen enlarged approximately two times; Late Cretaceous, (Maastrichtian), Pierre Shale, Mobridge Member, Sitting Bull Locality, Corson County, south Dakota.

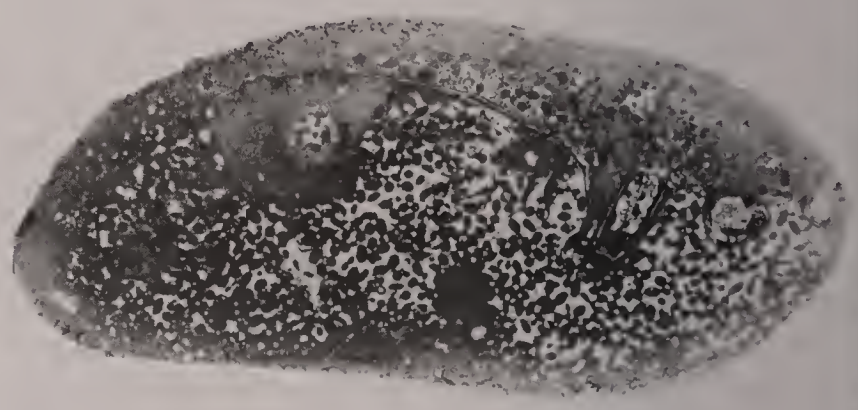

Fig. 2 - Transverse thin section of a concretion containing a complete fossil crab, *Dakoticancer overanus* Rathbun, 1917. Carapace and legs of the crab are seen in cross section surrounded by large oval fecal pellets within and around the crab, a worm burrow is present within the carapace and near the sternum (not preserved), and open space between pellets is filled with a clear mineral, possibly barite. The tiny granular crystallites surrounding the fecal pellets above the carapace and around the circular worm burrow within the carapace are thought to be hydroxy-apatite grains derived from precipitation of polyphospate inclusions similar to those figured by Schultz & Schultz, 2005 (Fig. 3).

References

Bishop G. A., 1981 – Occurrence and fossilization of the *Dakoticancer* Assemblage, Upper Cretaceous Pierre Shale, South Dakota. In: Communities of the Past, Gray et al. (eds.), *Hutchinson Ross Publishing Company*.

Bishop G. A., 1986 – Taphonomy of the North American decapods. *Journal of Crustacean Biology*, 6 (3): 326-355.

Bishop G. A., 1987 – Positive taphonomic feedback in North American Tethyan Cretaceous decapod-worm associations. In: Shallow Tethys 2. K. McKenzie (ed.). *Balkema Press,* Rotterdam.

Bishop G. A., Feldmann R. M. & Vega F., 1998 – The Dakoticancridae (Decapoda, Brachyura) from the Late Cretaceous of North America and Mexico. *Contributions to Zoology*, 67 (4): 237-255.

Bishop G. A. & Williams A. B., 1986 – The fossil lobster *Linuparus canadensis*, Carlile Shale (Cretaceous, Turonian), Black Hills. *National Geographic Research*, 2 (3): 372-387.

Bishop G. A. & Williams A. B., 2005 – Taphonomy and Preservation of Burrowing Thalassinidean Shrimps. *Proceedings of the Biological Society of Washington*, Washington, 118 (1): 218-236.

Maier S. & Gallardo V. A., 1984 – *Thioploca araucae* sp. nov. and *Thioploca chileae* sp. nov. *International Journal of Systematic Bacteriolology*, 34: 414.

Nelson D. C., Revsbech N. P. & Jørgensen B. B., 1986 – Microoxic-anoxic niche of *Beggiatoa* spp.: microelectrode survey of marine and fresh-water strains. *Applied and Environmental Microbiology*, 52: 161-168.

Schulz H. N., Brinkhoff T., Ferdelman T. G., Hernandez M., Teske M. A. & Jørgensen B. B., 1999 – Dense Populations of a Giant Sulfur Bacterium in Namibian Shelf Sediments. *Science*, 284: 493-495.

Schultz H. N. & Schultz H. D., 2005 – Large Sulfur Bacteria and the Formation of Phosphorite. *Science*, 307: 416-418.

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Volume XXXV – Fascicolo II

Gérard Breton & Joe S. H. Collins

Decapod fauna from the Cenomanian stratotype

During the 19th century, the stratotypic Cenomanian, *i.e.* the Sarthe department in France, around the town of Le Mans, provided local collectors such as J. Triger and E. Guéranger (Breton, 1996) a large amount of well preserved fossils. Among them, decapods in particular were collected from the so-called "Couche à Crustacés" in the "carrière de la Butte de Gazonfier" within the town of Le Mans. The "Couche à Crustacés" is located in the first lowest meters of the Sables du Perche Formation, Middle-Upper Cenomanian, Jukesbrownei-Guerangeri biozones. This quarry (section *in* Guinot & Breton, 2006) has been disused since the early 20th century. Other formations in the stratotype area provided decapods: Lower Cenomanian, Marnes de Ballon Formation, Carcitanensis and base of Saxbii biozones; Sables & Grès de Lamnay Formation, around Lamnay and St. Maixent, limit of the Mantelli and Dixoni biozones. Owing to their equal richness in crustaceans, Triger (*in* de Hennezel, 1858) erroneously correlated the Marnes de Ballon with the Couche à Crustacés in the Sables du Perche; in the museum collections, the two origins are often mixed. For the geological context and history, see Guinot & Breton (2006); for the stratigraphical correlations, see Juignet (1974, 1980).

Because the Butte quarry is now disused, fresh decapod material is rare, and most of the specimens noted here come from museum collections: Muséum d'Histoire naturelle, Le Havre (MHNH); Musée d'Histoire naturelle Le Mans (register numbers MHN LM 2003-1-XXXX abbreviated here LMXXXX); Muséum national d'Histoire naturelle, Paris, Domaine des Sciences de la Terre (MNHN); Laboratoire de Géologie, Université de Caen (LGUC); Université Lyon I (FSL); Université de Paris VI (UPMC).

Principal publications concerning the study of these Cenomanian decapods include works of A. Milne Edwards (1861, 1862a, 1862b, 1882), A. Milne Edwards & Brocchi (1879), Brocchi (1887), Van Straelen (1936), and Guinot & Breton (2006).

The most frequently encountered macruran is *Hoploparia trigeri* (Van Straelen 1936) of which we here designate as the lectotype the specimen figured as "topotype" by Van Straelen (1936, pl. 3, fig. 4) [LM3760] from La Butte quarry. Other specimens are: LM3799A and MNHN A25925 (Fig. 1) with elongated chelipedes (first known occurrence of associated chelae), LM3801 juvenile, LM3785 has an irregular bopyriform swelling, UPMC unregistered [from La Butte quarry], MNHN A25926, [from St-Mars-sous-Ballon].

The palinurid *Linuparus dentatus* Van Straelen, 1936 [*non* 1931] is far less frequent. The 1931 paper of Van Straelen has not been found, either in the Van Straelen's library in the MNHN, Paris, or in Bruxelles (J.-M. Bragard, pers. comm.) and it is not quoted in his bibliographic list (Corin, 1965): the citation of this 1931 paper is supposed to be erroneous, thus we retain the date, 1936, for this species. We designate as lectotype the specimen figured by Van Straelen (1936, pl. I, fig. 2) [MNHN R03384]. A plaster cast of the lectotype [LM3781] and fragmentary specimens [LM3789].

Callianassa cenomaniensis A. Milne Edwards, 1861. We have not been able to find the specimen(s) drawn by A. Milne Edwards (1861, pl. 14, fig. 5, 5A), therefore we designate as lectotype the specimen figured here Fig. 2 [MNHN R03548], which fits well the original description. It is labelled "1902-3" like other specimens studied by A. Milne Edwards and it comes from the type locality: St-Mars-sous-Ballon, Lower Cenomanian. The matrix, a fine glauconitic limestone with one *Orbitolina concava* (Lamarck 1816) proves it comes from the Marnes de Ballon Formation. This species is fairly abundant throughout the stratotypic Cenomanian and there are numerous specimens in MHN LM, MNHN, FSL, mainly from Marnes de Ballon, but also from Sables du Perche Formation.

Porcellana antiqua A. Milne Edwards, 1882 is considered as a *nomen dubium* because the original description is based on a single specimen, not illustrated, which has not been found.

Pagurus sp.? [MNHN B16584B]. A small hermit crab is preserved in the aperture of an unidentified, diagenetically compressed gastropod shell. It displays fragmentary appendages: the incomplete punctuated right chela seems to be larger than the left one (Fig. 3). Such preservation is rare (Jagt *et al.*, 2006; Todd & Collins, 2005). Labelled "Crustacé de la Sarthe communiqué par M. Triger 1902-3. Crétacé sup", it probably comes from the Carrière de la Butte, but not from the Couche à Crustacés. The matrix, a grey soft clay with ferrugineous staining, and the type of fossilization with a complete decalcification evoke the "Lentilles à Echinodermes", 10 meters or so below the Couche à Crustacés, within the Sables & Grès du Mans Formation (Breton, 1996; Guinot & Breton, 2006: fig. 1).

Caloxanthus formosus A. Milne Edwards, 1862. There are a few specimens, of both carapaces and chelipeds. No ventral side is known. [LM3792 (carapace); LM3796, 3797 (chelipeds); MNHN R03351 (carapace), B16572 (carapace and associated chelipeds)].

Trachynotocarcinus sulcatus (Bell, 1863). One incomplete small carapace [MNHN B16571], Upper Cenomanian, Saint-Calais (Sarthe).

Raninella trigeri A. Milne Edwards, 1862. Type species of the genus *Raninella*, by original designation. Although this species, and the following one are both named by A. Milne Edwards (1862b), and adequately distinguished in barely two lines, this sufficiently constitutes a definition of both taxa in respect to art. 12.1 of ICZN. "this, though jejune, is just adequate to make the name available" (Wright & Collins, 1972). We designate as the lectotype the specimen MNHN B16565, figured by Brocchi (1877, pl. 29, figs. 1, 2). Paralectotype MNHN R0394 figured by Brocchi (1877, pl. 29, fig. 3). Other specimens and casts of type material in MHN LM. Their matrix shows that all specimens come from the Carrière de la Butte, Couche à Crustacés.

Raninella elongata A. Milne Edwards, 1862. The differences with *R. trigeri* are well explained by Brocchi (1877). *Raninella elongata* is always smaller than *R. trigeri*, and we have not seen any intermediate sized *Raninella* in the collections we visited. Thus we do not agree with Van Straelen (1936) who stated that *R. elongata* and *R. trigeri* are synonymous, the former being a juvenile of the latter. Type series in MNHN, formerly B16575 with 5 specimens from Sables du Perche Fm, La Butte quarry and 4 specimens from Marnes de Ballon Fm, with a single label "Crustacés des Grès verts du Mans A. Milne Edwards 1902-3". Among them, we designate as lectotype MNHN A25922 the specimen figured by Brocchi (1877, pl. 29, figs. 4, 5), La Butte quarry. Paralectotypes are: MNHN A25923, figured pl. 29, fig. 5 bis, Ballon; 3 specimens MNHN B16575, La Butte; 4 specimens MNHN A25924, Ballon; other paralectotypes: 2 specimens labelled "Raninella Trigeri A. M. Edw. Cénomanien Le Mans Sarthe 1902-3", B16564, La Butte quarry. Other specimens LM3788.

Raninidae gen. nov., sp. nov. from the Lower Cenomanian Sables & Grès de Lamnay Fm, St-Maixent (Sarthe), two specimens that will be described and named later: Collins & Breton (in progress).

Cenomanocarcinus inflatus Van Straelen, 1936. Figured as *Necrocarcinus inflatus* (*nomen nudum:* ICZN 13.1.1) by Boule & Piveteau (1935), fig. 670. We designate as lectotype the specimen figured by Van Straelen (1936, pl. IV, fig. 8) [MNHN J08587 ex coll. Hébert, labelled "La Butte de Gazonfier au Mans"]. Other material: MNHN R05504 (paralectotype), MNHN B16588a: anterior fragment of the carapace, with associated left cheliped (Fig. 4), LM3780, 3805, 3806, a juvenile with produced epibranchial, posterolaterally directed, spines which, in combination with the triple row of tubercles, gives it a calappid-like appearance (Fig. 5). These spines are broken in all other specimens, giving them a more rounded outline.

Necrocarcinus labeschii (Deslongchamps, 1835). One specimen (carapace length 19mm; width: 24mm), Sables du Perche Formation, Le Mans [LM3808, coll. Guéranger]. Two small cephalothoraces [one at least presumably from Sables du Perche Fm], ca 12 x 12mm [LM3807] are labelled "*Necrocarcinus minutus* M. Edw.". *Necrocarcinus minutus* is a *nomen nudum* in Guillier (1886). These two specimens seem to be juveniles of *N. labeschii* (Fig. 6).

Lithophylax trigeri A. Milne Edwards & Brocchi, 1879. Lectotype MNHN A25835 selected among the type series by Guinot & Breton (2006). For a complete description, see Guinot & Breton (2006). This small crab, which has a stridulating apparatus and was coprophagic (Breton, 2006), is by far the most abundant decapod from the stratotypic Cenomanian: many specimens in MNHN, MHN LM, MHNH, LGUC, Muséum de Rouen: coll. Fortin 31217, Natural History Museum in Bruxelles (B), and the Natural History Museum (UK).

Xanthosia sp.? One specimen, without any indication of origin, but within the Guéranger collection [LM3798] may come from the Sables du Perche Formation.

The decapod fauna from the Cenomanian stratotype is varied, and contains apparently endemic species. Among the 14 taxa quoted here, 10 were found in the Carrière de la Butte, Sables du Perche Formation, Couche à Crustacés. But *Lithophylax trigeri* is also found in the Cenomanian from the Aude department, south France (Van Bakel, Artal, Breton, Guinot & Vizcaïno, in progress). *Trachynotocarcinus sulcatus* is also known from England (Wright & Collins, 1972) and from Normandy (Breton, unpublished). *Caloxanthus formosus* is also found in Normandy (Breton, unpublished) and in the south of France (Van Straelen, 1938). *Callianassa cenomaniensis* was collected in Normandy, and *Raninella trigeri* and *Cenomanocarcinus inflatus* were found in the south of France (Van Straelen, 1936, 1938). *Necrocarcinus labeschii* is widespread in England and France (Wright & Collins, 1972). The other species seem to be restricted to Le Mans area, but they are indeed the rarest.

The apparent endemism among stratotypic Cenomanian decapod fauna is undoubtedly due to the peculiar palaeoenvironmental and taphonomic conditions which led to the "Couches à Crustacés" *Konservat-Lagerstätte*. As in the case of recently discovered *Lithophylax trigeri* outside the type area mentioned above, subsequent collecting could well produce a wider distribution of "pseudo-endemic" species.

Fig. 1 - *Hoploparia trigeri* (Van Straelen, 1936). MNHN A25925. Middle - Upper Cenomanian, Sables du Perche Formation, "Couches à Crustacés" beds, La Butte quarry, Le Mans (Sarthe, France). Moult with right cheliped. Scale bar: 1 cm.

Fig. 2 - *Callianassa cenomaniensis* A. Milne Edwards, 1861. Lectotype, MNHN R03548. Lower Cenomanian, Marnes de Ballon Formation, Saint-Mars-sous-Ballon (Sarthe, France). Scale bar: 1 cm.

Fig. 3 - *Pagurus* sp.? MNHN B16584B. Probably Middle - Upper Cenomanian, Sables & Grès du Mans Formation, "Couches à Echinodermes" beds, La Butte quarry, Le Mans (Sarthe, France). Scale bar: 5 mm.

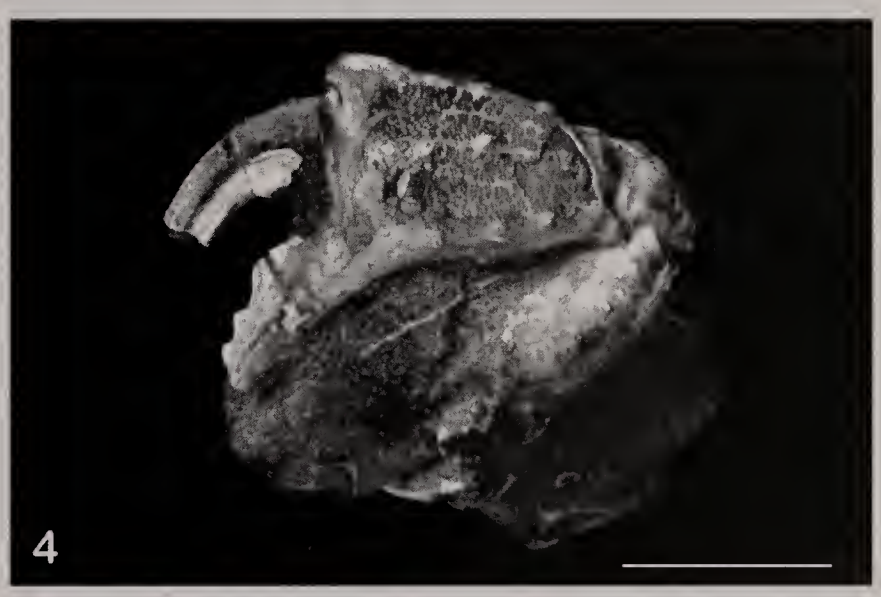

Fig. 4 - *Cenomanocarcinus inflatus* Van Straelen, 1936. Paralectoptype, MHNH B16588a. Probably Middle - Upper Cenomanian, Sables du Perche Formation, "Couches à Crustacés" beds, La Butte quarry, Le Mans (Sarthe, France). Cheliped. Scale bar: 1 cm.

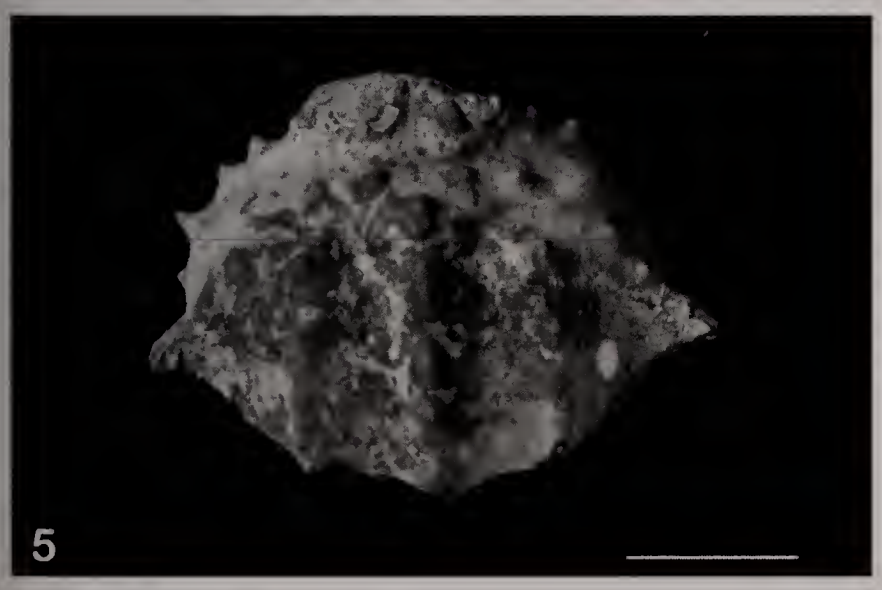

Fig. 5 - *Cenomanocarcinus inflatus* Van Straelen, 1936. LM 3806, coll. Guéranger. Middle - Upper Cenomanian, Sables du Perche Formation, "Couches à Crustacés" beds, La Butte quarry, Le Mans (Sarthe, France). Carapace of a young individual with pronounced epibranchial spines. Scale bar: 1 cm.

Fig. 6 - *Necrocarcinus labeschii* (Deslongchamps, 1835). LM 3807, coll. Guéranger, labelled as "*Necrocarcinus minutus* M. Edw."[*nomen nudum* in Guillier (1886)]. Probably Lower Cenomanian, Marnes de Ballon Formation, Ballon (Sarthe, France). Carapace of a very young individual. Scale bar: 5 mm.

References

Boule M. & Piveteau J., 1935 – Les Fossiles - Eléments de paléontologie. *Masson & Cie*, Paris.

Breton G., 1996 – *Tethyaster guerangeri* sp. nov. (Astropectinidae, Asteroidea, Echinodermata): deux spécimens d'astérides d'une conservation exceptionnelle du Cénomanien du Mans (Sarthe, France). *Bulletin de la Société Géologique de Normandie et des Amis du Muséum du Havre*, Le Havre, 82 (4), 1995 (1996): 17-29.

Breton G., 2006 – Un cas de paléocoprophagie chez un crabe du Cénomanien du Mans (collection Boutillier, Université de Caen). *Bulletin de la Société linnéeenne de Normandie*, Caen, 119: 41-43.

Brocchi P., 1877 – Description de quelques Crustacés fossiles appartenant à la tribu des Raniniens. *Annales des Sciences Géologique,* Paris, 8: 1-8.

Corin F., 1965 – Victor Van Straelen (14 juin 1889 - 29 février 1964) [Notices nécrologiques]. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, Bruxelles,74: 12-35.

Guillier A., 1886 – Géologie du Département de la Sarthe. *Monnoyer*, Le Mans.

Guinot D. & Breton G., 2006 – *Lithophylax trigeri* A. Milne-Edwards & Brocchi, 1879 from the French Cretaceous (Cenomanian) and placement of family Lithophylacidae Van Straelen, 1936 (Crustacea, Decapoda, Brachyura). *Geodiversitas*, Paris, 28 (4): 591- 633.

Jagt J. W. M., van Bakel B. W. M., Fraaije R. H. B. & Neumann C., 2006 – *In situ* fossil hermit crabs (Paguroidea) from northwest Europe and Russia. Preliminary data on new records. *Revista Mexicana de Ciencias Geológicas*, Mexico, 23, 3: 464-469.

Juignet P., 1974 – La transgression crétacée sur la bordure orientale du Massif armoricain. Aptien, Albien, Cénomanien de Normandie et du Maine. Le stratotype du Cénomanien. Thèse de Doctorat d'Etat, Université de Caen (unpublished).

Juignet P., 1980 – Cénomanien. In: Synthèse géologique du Bassin de Paris. Volume I. Statigraphie et paléogéographie. Mégnien C. & Mégnien F. (eds.). *Mémoire BRGM,* Paris, 101: 292-297.

Milne Edwards A., 1861 – Histoire des Crustacés Podophtalmaires fossiles. *Victor Masson & fils*, Paris, 1.

Milne Edwards A., 1862a – Monographie des Crustacés fossiles de la famille des Cancériens. Première Partie. *Annales des Sciences Naturelles* (Zoologie), Paris, 4 (18): 31-85.

Milne Edwards A., 1862b – Sur l'existence de Crustacés de la famille des Raniniens pendant la période crétacée. *Comptes rendus hebdomadaires des Séances de l'Académie des Science*, Paris, 55: 492-494.

Milne Edwards A., 1882 – Note sur un Crustacé du terrain crétacé appartenant au genre *Porcellana*. *Annales de Sciences géologiques*, Paris, 12: 52 [with a mistake in the pagination: p. 42 inserted at a wrong place in the same fascicle]

Milne Edwards A. & Brocchi P., 1879 – Note sur quelques Crustacés fossiles appartenant au groupe des Macrophthalmiens. *Bulletin de la Société Philomatique de Paris*, Paris, 7 (3): 113-117.

Van Straelen V., 1936 – Crustacés Décapodes nouveaux ou peu connus de l'époque crétacique. *Bulletin du Musée royal d'Histoire naturelle de Belgique*, Bruxelles, 12 (45): 1-50.

Van Straelen V., 1938 – La faune carcinologique du Crétacique des Corbières méridionales. *Compte Rendu sommaire des Séances de la Société géologique de France*, Paris, 1938 (9): 151-153.

Todd J. & Collins J. S. H., 2005 – Neogene and Quaternary crabs (Crustacea, Decapoda) collected from Costa Rica and Panama by members of the Panama Palaeontological project. *Bulletin of the Mizunami Fossil Museum*, Mizunami, 32: 53-85.

Triger J., 1858 – Note sur la composition du terrain crétacé du département de la Sarthe In: de Hennezel (ed.). *Bulletin de la Société d'Agriculture, Sciences et Arts de la Sarthe*, Le Mans, 2 (13): 201-211.

Wright C. W. & Collins J. S. H., 1972 – British Cretaceous crabs. *Palaeontographical Society* (*Monographs*), London, 533: 1-114.

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Antonio De Angeli & Claudio Beschin

Tertiary stomatopods from Italy

De Angeli & Garassino (2006) reported Decapoda and Stomatopoda from the Triassic to Pleistocene of Italy, pointing out that the stomatopods are very rare and usually incomplete in the fossil record. De Angeli & Beschin (2006) described two new species of stomatopods, giving a check list of Tertiary species from Veneto. The Tertiary species known to date are the following: *Pseudosquilla berica* De Angeli & Messina, 1996 (lower Oligocene, Perarolo – Vicenza) (Pseudosquillidae Manning, 1977); *Lysiosquilla antiqua* (Münster, 1842) (lower-middle Eocene, Monte Bolca – Verona), *Lysiosquilla messinai* De Angeli, 1997 (lower Oligocene, Perarolo – Vicenza), *Lysiosquilla* sp. (middle Eocene, Laverda – Vicenza) (Lysiosquillidae Giesbrecht, 1910); *Coronidopsis albanellensis* De Angeli & Beschin, 2006 (middle Eocene, Chiampo Valley – Vicenza) (Eurysquillidae Manning, 1977); *Squilla miocenica* Lovisato, 1894 (Miocene, Cagliari – Sardinia), *Squilla breoniensis* De Angeli & Beschin, 2006 (middle Eocene, Breonio – Verona) (Squillidae Latreille, 1802).

Pseudosquilla berica De Angeli & Messina, 1996 (lower Oligocene, Perarolo – Vicenza) has a convex carapace transversely marked by two longitudinal grooves, rostrum with rounded margin, thoracic somites smooth, abdominal somites III-V marked by a longitudinal groove, abdominal somite V with posterior carina, abdominal somite VI with four small posterior spines, and telson with median carina and six marginal teeth. The shapes of the right exopod and endopod, raptorial claw, and eyestalk are known, too.

Lysiosquilla antiqua (Münster, 1842) (lower-middle Eocene, Monte Bolca) was described on the morphological characters of the holotype which is lost. Later, Secretan (1975) gave a new description of this species based upon many specimens, housed in the Museo di Storia Naturale di Verona and Museo di Geologia e Paleontologia dell'Università di Padova. Schram & Müller (2004) considered *L. antiqua minor* Secretan, 1975, to be a synonym with *L. antiqua* (Münster, 1842).

Lysiosquilla messinai De Angeli, 1997 (lower Oligocene, Perarolo – Vicenza) has a carapace longer than wide, pentagonal rostrum, abdominal somites with curved margin, subrectangular and flat telson with weak median carina and small marginal teeth. Besides the stomatopods, anomurans (*Upogebia perarolensis* De Angeli & Messina, 1992, and *Galathea valmaranensis* De Angeli & Garassino, 2002), isopods (*Cirolana fabianii* De Angeli & Rossi, 2006) and mysidaceans (*Mysidopsis oligocenicus* De Angeli & Rossi, 2006) were described from Perarolo (De Angeli & Messina, 1992, 1996, 1997; De Angeli, 1997; De Angeli & Rossi, 2006).

Lysiosquilla sp. (lower Lutetian, Laverda – Vicenza) was described from a single dactylus of the raptorial claw. De Angeli & Beschin (2006) also reported the brachyurans *Harpactocarcinus punctulatus* (Desmarest) and *Palaeograpsus inflatus* Bittner from this locality.

Coronidopsis albanellensis De Angeli & Beschin, 2006 (middle Eocene of "Albanello" quarry, Nogarole Vicentino – Vicenza) has abdominal somites subrectangular and smooth, with a latero-posterior pleural widening, telson with two weak submedian carinae, raptorial claws with elongate propodus having three spines, and dactylus with three strong spines, besides the elongate distal spine. Beschin *et al.* (2005) reported one dactylus from Grola di Cornedo Vicentino (Vicenza) beloning to *C. albanellensis*. *Coronidopsis albanellensis* was ascribed to *Coronidopsis* for the abdomen, smooth telson without carinae, and four spines of dactylus of the raptorial claw. *Coronidopsis* is known from two Recent species *C. bicuspis* Hansen, 1926, and *C. serenei* Moosa, 1973, widespread in Indo-Pacific area, New Caledonia, and Australia.

Squilla breoniensis De Angeli & Beschin, 2006 (middle Eocene, Breonio – Verona) has an elongate carapace with marked cervical groove, and short posterior median ridge, abdominal somites with a pair of submedian, intermedian, and lateral ridges, telson with median carina and serrate lateral margins, raptorial claws with propodus having small spines along the margins, and a dactylus with four-five strong spines. *Squilla* is known from the Cretaceous to the Recent with seven fossil species, *S. breoniensis*, *S. cretacea* Schlüter, 1868, *S. hollandi* Förster, 1982, *S. laingae* Hof & Schram, 1998, *S. miocenica* Lovisato, 1894, *S. sonomana* (Rathbun, 1926), and *Squilla* sp., and 23 Recent species (Schram & Müller, 2004).

Squilla miocenica Lovisato, 1894 (Miocene, Fangario – Sardinia) was described by Lovisato (1894, figs. 1-3) on morphological characters of some dactyli with eight spines (including the elongate spine). Via Boada (1949) also reported this species from the Miocene of Spain.

Six species known to date in Italy come from Veneto, attesting to the importance of the Eocene and Oligocene quarries of this area, very rich of decapods, useful to establish a relationship between the fossil and Recent taxa.

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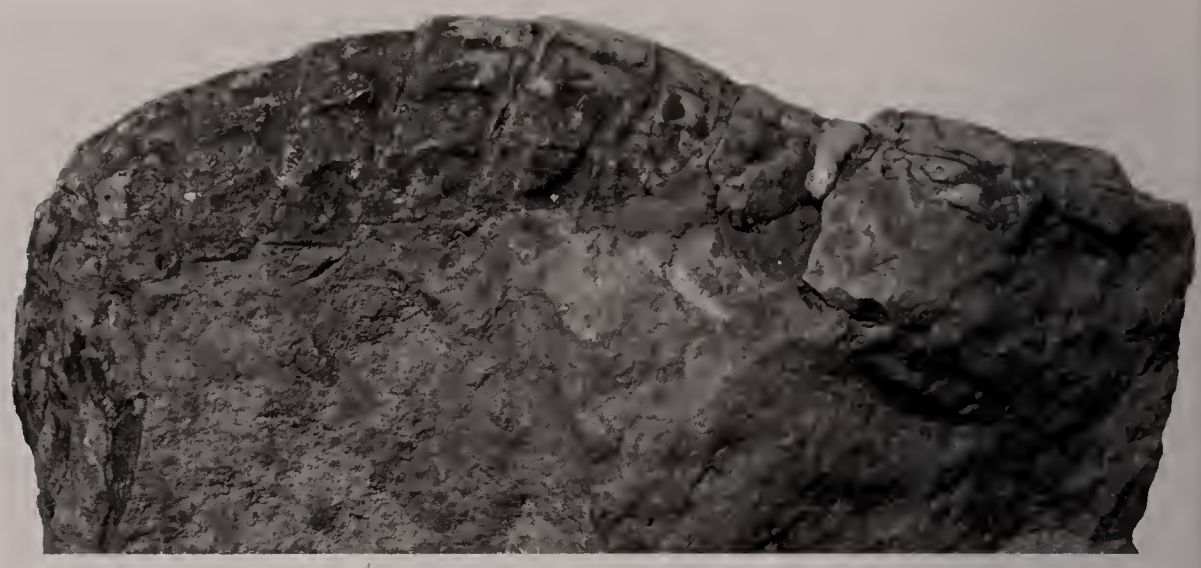

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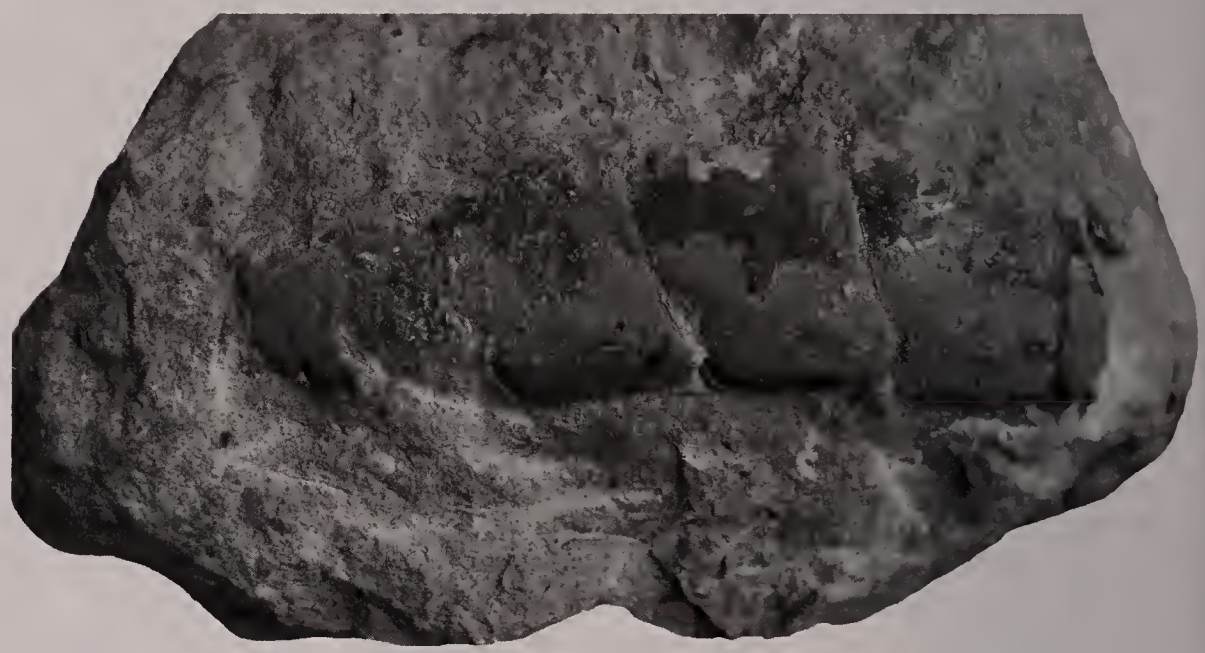

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Fig. 1 – A-B) *Squilla breoniensis* De Angeli & Beschin, 2006, holotype, n. cat. MCZ 1552 - I.G. 284630. A) Lateral view. B) Dorsal view. C-E) *Coronidopsis albanellensis* De Angeli & Beschin, 2006, holotype, n. cat. MCZ 1542 - I.G. 284620. C) Dorsal view. D) Lateral view. E) Raptorial claw.

References

Beschin C., De Angeli A., Checchi A. & Zarantonello G., 2005 – Crostacei eocenici di Grola presso Spagnago (Vicenza, Italia settentrionale). *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 12: 5-35.

De Angeli A., 1997 – *Lysiosquilla messinae*, nuova specie di crostaceo stomatopode del Terziario di Vicenza (Nord Italia). *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1997: 23-26.

De Angeli A. & Beschin C., 2006 – Stomatopodi terziari del Veneto (Italia settentrionale). *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 13: 19-28.

De Angeli A. & Garassino A., 2006 – Catalog and bibliography of the fossil Stomatopoda and Decapoda from Italy. *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 35 (1): 1-95.

De Angeli A. & Messina V., 1992 – *Upogebia pererolensis* nuova specie di crostaceo del Terziario del Veneto (Italia). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 17: 183-191.

De Angeli A. & Messina V., 1996 – *Pseudosquilla berica* nuova specie di Stomatopoda del Terziario Veneto. *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1996: 5-10.

De Angeli A. & Messina V., 1997 – *Galathea weinfurteri* Bachmayer, 1950 (Crustacea, Anomura) nell'Oligocene di Perarolo (Vicenza, Nord Italia). *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 1997: 17-21.

De Angeli A. & Rossi A., 2006 – Crostacei oligocenici di Perarolo (Vicenza - Italia settentrionale), con la descrizione di una nuova specie di Mysida e di Isopoda. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 31: 85-93.

Lovisato D., 1894 – Avanzi di *Squilla* nel Miocene medio di Sardegna. *Rendiconti della Reale Accademia dei Lincei*, Roma, III, 4: 205-209.

Schram F. R. & Müller H-G., 2004 – Catalog and bibliography of the fossil and recent Stomatopoda. *Backhuys publishers*, Leiden, The Netherlands.

Secretan S., 1975 – Les Crustacés du Monte Bolca. *Museo Civico di Storia Naturale di Verona – Studi e Ricerche sui giacimenti terziari di Bolca,* Verona, 2: 315-425.

Via Boada L., 1949 – Un resto de estomatópodo (*Squilla miocenica* Lovisato) en las margas tortonienses de Montjuich. *Bulletin de la Istitució Catalana Història Natural*, Barcellona, 37: 2-4.

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Antonio De Angeli & Alessandro Garassino

Decapod crustaceans from the Mesozoic and Cenozoic of Friuli-Venezia Giulia (NE Italy)

The study of brachyurans and anomurans from the Mesozoic and Cenozoic of Friuli-Venezia Giulia (NE Italy) was previously limited to only two reports by Dainelli (1915), and Collins & Dieni (1995). Dainelli (1915) reported four incomplete specimens of *Lophoranina marestiana* (König, 1825) from the Eocene of Buttrio and Valle del Natisone (Udine), two specimens of *Palaeocarpilius macrochelus* (Desmarest, 1822) from Monte Plauris (Udine), and one specimen of *Panopeus vicentinus* Bittner, 1875, from Buttrio. Collins and Dieni (1995) reported one incomplete chela of indeterminate pagurid and one incomplete carapace ascribed to *Graptocarcinus bellonii* Collins & Dieni, 1995, from the Upper Cretaceous (Cenomanian) of Col dei Schiosi (Altopiano del Cansiglio, Pordenone).

The recent discovery of thalassinids, anomurans, and brachyurans from some localities, Altopiano Prat, Casali Ottelio, and Borgo Vigant (Udine province), Val Caltea, Monte Ciaurlec, Almadis, and Meduno (Pordenone province) permitted increasing of the carcinologic knowledge about these systematic groups (De Angeli & Garassino, 2006).

The studied sample included *Corallianassa rigoi* De Angeli & Garasino, 2006 (infraorder Thalassinidea Latreille, 1831), *Calteagalathea friulana* De Angeli & Garassino, 2006 (infraorder Anomura MacLeay, 1838), *Pithonoton marginatum* (v. Meyer, 1842), *Graptocarcinus bellonii* Collins & Dieni, 1995, *Lophoranina marestiana* (König, 1825), *Portunus monspeliensis* (A. Milne Edwards, 1860), *Portunites rosenfeldi* De Angeli & Garassino, 2006, and *Titanocarcinus raulinianus* A. Milne Edwards, 1863 (infraorder Brachyura Latreille, 1802).

Some chelae were ascribed to *Corallianassa rigoi* from the Cretaceous (Aptian-Campanian) of Monte Ciaurlec (Pordenone). The oldest fossil species belonging to this genus is *C. acucurvata* Swen, Fraaije & Van der Zwaan, 2001, from the Upper Cretaceous (Maastrichtian) of Maastricht (The Netherlands) (Swen *et al.,* 2001). *Co rallianassa acucurvata* differs from *C. rigoi* by the smooth lower margin of the bigger chela, and by the fixed and movable fingers being more elongate. *Corallianassa* sp. from the Paleocene (upper Danian) of Copenhagen (Denmark), described by Rasmussen (1971) is also assigned to this genus. The Danish species differs from *C. rigoi* by the bigger chela with more sinuous lower margin, and by the fixed and movable fingers being more developed. The discovery of *C. rigoi* is very important because it represents the first report of this genus in Italy, attesting to the widespread distribution of *Corallianassa* in the European seas during the Upper Cretaceous.

Calteagalathea friulana, from the Upper Cretaceous (Maastrichtian) of Val Caltea (Pordenone), represents the oldest galatheid known to date in Italy, showing morphological affinities with the representatives of *Paragalathea*, which is widespread in the Upper Jurassic and Cretaceous of Europe. A comparison between *C. friulana* and some pictures of the holotype of *P. multisquamata* Via Boada, 1981, housed in the Seminary Museum of Barcelona, suggested that the Spanish species had a wider and more curved cervical groove, smaller, thicker, and more uniform granulation, more rectilinear lateral margins, and less deep postcervical depression.

The discovery of *Pithonoton marginatum* (v. Meyer, 1842) from the Upper Jurassic (Oxfordian-Kimmeridgian) of Altopiano Prat (Udine) was very interesting since this prosopid represents the oldest brachyuran known to date in Italy. The discovery of prosopids in Italy was until now limited to the Tithonian of Sicily (Gemmellaro, 1869) with *Pithonoton bidentatum* (Reuss, 1859) (= *Prosopon etalloni* Gemmellaro *in* Gemmellaro, 1869), and *Pithonoton grande* (v. Meyer, 1860) (= *Prosopon polyphemi* Gemmellaro *in* Gemmellaro, 1869). The report of prosopids from the Upper Jurassic of Friuli-Venezia Giulia extended the geographical distribution of these decapods also into N Italy.

The discovery of one well-preserved specimen of *Graptocarcinus bellonii* attested to the spread of this dynomenid in the Upper Cretaceous (Maastrichtian) of Friuli-Venezia Giulia, species already described by Collins & Dieni (1995), from the Upper Cretaceous (Cenomanian) of Col dei Schiosi (Altopiano del Cansiglio, Pordenone). However, a comparison with the holotype (DGP. B241), housed in the Museo di Geologia e Paleontologia dell'Università degli Studi di Padova, resulted in the following observations: the studied specimen is more complete than the holotype, lacking only the fronto-orbital and anterolateral margins; the dorsal ornamentation of the studied specimen is less uniform; the branchial, hepatic, and gastric regions of the studied specimen have smaller tubercles, while the tubercles are rare in the median part. The different ornamentation of the surface of the carapace between the holotype and the studied specimen could be related to different onthogenetic stages since the carapace of the studied specimen is three time larger than that of the holotype.

The discovery of new specimens of *Lophoranina marestiana* (König, 1825) attested to the widespread distribution of this species in the Eocene of Friuli-Venezia Giulia, where it was already known by four

Fig. 1 – A) *Corallianassa rigoi* De Angeli & Garassino, 2006. B) *Calteagalathea friulana* De Angeli & Garassino, 2006, holotype. C) *Pithonoton marginatum* (v. Meyer, 1842). D) *Portunites rosenfeldi* De Angeli & Garassino, 2006. E) *Graptocarcinus bellonii* Collins & Dieni, 1995. F) *Titanocarcinus raulinianus* A. Milne Edwards, 1863.

incomplete carapaces, discovered in Buttrio and Valle del Natisone by Tellini and reported by Dainelli (1915). *Lophoranina marestiana* is particularly widespread in the Cuisian and Lutetian levels of Veneto (Beschin *et al.*, 1988).

The discovery of some specimens of *Portunus monspeliensis* (A. Milne Edwards, 1860) (= *P. granulatus* A. Milne Edwards, 1860) from the middle Miocene (Langhian) of Meduno (Pordenone) is important because this species is reported for the first time in Friuli-Venezia Giulia and its presence attests to the widespread distribution of this portunid in the Mediterranean Sea during the Miocene. This species is known from the Miocene of S Europe (Hungary, France, Austria) and N Africa (Egypt), while Ristori (1888), Lörenthey (1909), Comaschi Caria (1950, 1956), and Marras & Ventura (1991) reported this species in Italy from the Miocene of Sardinia and Emilia Romagna. The presence of *P. monspeliensis* from the Rupelian (lower Oligocene) of Bacino Ligure Piemontese is dubious. In fact, Allasinaz (1987) pointed out that the specimens of this species, discovered in Piedmont, could belong to a subspecies similar to *P. monspeliensis*.

Portunites Bell, 1858, known to date from the Eocene of N Europe, N Africa, Japan and N America, is reported for the first time in Italy with *P. rosenfeldi*. Schweitzer & Feldmann (2000) discussed *Portunites* Bell, 1858, known in the fossil record with eight species. *Portunites rosenfeldi* differs from the known fossil species in terms of the location of the epibranchial rise creating a wide transverse convexity, wider and angled at the margins of the protogastric regions.

Finally, *Titanocarcinus raulinianus* A. Milne Edwards, 1863, was reported by A. Milne Edwards (1863), Lörenthey (1898), and Lörenthey & Beurlen (1929) from the middle Eocene of France and from the late Eocene of Hungary, while Ristori (1893), Di Salvo (1933), and Beschin *et al.* (2000) reported this species in Italy from the lower Eocene of the Gecchelina quarry of Monte di Malo (Vicenza), and from the middle Eocene of Monte Saraceno (Gargano, Puglia) and Monreale (Sicily). *Titanocarcinus* includes many species from the Cretaceous to Miocene (Glaessner, 1969). We pointed out that *T. subovalis* Ristori, 1896, from the Pliocene of Tuscany possessed a shape and dorsal characters of the carapace that are different from those of *Titanocarcinus*, while *T. sculptus* Ristori, 1891, from the Pliocene of Mucigliani (Siena), is a synonym with *Chlinocephalus demissifrons* Ristori, 1886 (Garassino *et al.*, 2004).

References

Allasinaz A., 1987 – Brachyura decapoda oligocenici (Rupeliano) del Bacino Ligure Piemontese. *Bollettino del Museo regionale di Scienze naturali di Torino*, Torino, 5 (2): 509-566.

Beschin C., Busulini A., De Angeli A. & Tessier G., 1988 – Raninidae del Terziario berico-lessineo (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 13: 155-215.

Beschin C., Busulini A., De Angeli A., Tessier G. & Ungaro S., 2000 – The fauna of the Gecchelina Quarry at Monte di Malo (Vicenza – Northern Italy): a preliminary study. In: 1st Workshop on Mesozoic and Tertiary decapod crustaceans. *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore: 7-12.

Collins J. S. H. & Dieni I., 1995 – New decapod crustaceans from the Cenomanian Rudist Limestones of NE Italy. *Bulletin of Mizunami Fossil Museum*, Mizunami, 22: 67-72.

Comaschi Caria I., 1950 – Crostacei Decapodi nel Miocene (Elveziano) di Bosa in Sardegna. *Rendiconto del Seminario della Facoltà di Scienze dell'Università di Cagliari*, Cagliari, 20 (3-4): 324-327.

Comaschi Caria I., 1956 – I Crostacei miocenici della Sardegna. *Bollettino del Servizio Geologico d'Italia*, Roma, 78 (1-2): 283-290.

Dainelli G., 1915 – L'Eocene Friulano – Monografia geologica e paleontologica. *Editrici le "Memorie Geografiche"*, Firenze.

De Angeli A. & Garassino A., 2006 – New reports of decapod crustaceans from the Mesozoic and Cenozoic of Friuli-Venezia Giulia (NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (2): 267-294.

Di Salvo G., 1933 – I Crostacei del Terziario inferiore della provincia di Palermo. *Giornale delle Scienze Naturali ed Economiche di Palermo*, Palermo, 37: 1-44.

Garassino A., De Angeli A., Gallo L. M. & Pasini G., 2004 – Brachyuran and anomuran fauna from the Cenozoic of Piedmont (NW Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 145 (2): 251-281.

Gemmellaro G. G., 1869 – Studi paleontologici sulla fauna del calcare a *Terebratula janitor* del Nord di Sicilia. *Stabilimento Tipografico Lao*, Palermo, Parte I.

Glaessner M. F., 1969 – Crustacea Decapoda. In: Treatise on Invertebrate Paleontology. Arthropoda 4 (2), *Geological Society of America and University of Kansas*, Lawrence: R399-R533, R626-R628.

Lörenthey I. E., 1898 – Beiträge zur Dekapodenfauna des Ungarischen Tertiärs. *Termes-Füzetek,* Budapest, 21: 1-133.

Lörenthey I. E., 1909 – Beiträge zur tertiären Dekapodenfauna Sardiniens. *Mathematischen und Naturwissenschaftlichen Berichte aus Ungarn*, Budapest, 24: 202-257.

Lörenthey I. & Beurlen K., 1929 – Die fossilen Dekapoden der Länder Ungarischen Krone. *Geologica Hungarica, Serie Palaeontologica*, Budapest, 3: 1-420.

Marras G. & Ventura G., 1991 – Crostacei decapodi del Miocene di Sassari (Sardegna nord-occiden-

tale). *Bollettino della Società Sarda di Scienze Naturali*, Sassari, 28: 105-119.

Milne Edwards A., 1862-1865 – Monographie des Crustacés fossiles de la famille des Cancériens. *Annales de Science Naturelle, Zoologie*, Paris, sér. 4, 18 (1862): 31-85; 20 (1863): 273-324; sér. 5, 1 (1864): 31-88; 3 (1865): 297-351.

Rasmussen H. W., 1971 – Echinoid and crustacean burrows and their diagenetic significance in the Maastrichtian-Danian of Stevns Klint, Denmark. *Lethaia*, Oslo, 4: 191-216.

Ristori G., 1888 – Alcuni Crostacei del Miocene medio italiano. *Atti della Società Toscana di Scienze Naturali*, Pisa, 9: 212-219.

Ristori G., 1893 – Il *Titanocarcinus raulinianus* A. M. Edw. negli strati nummulitici del Gargano. *Atti della Società Toscana di Scienze Naturali, Processi verbali*, Pisa, 7-8: 212-215.

Schweitzer C. E. & Feldmann R. M., 2000 – New fossil portunids from Washington, USA, and Argentina, and a re-evaluation of generic and family relationships within the Portunoidea Rafinesque, 1815 (Decapoda: Brachyura). *Journal of Paleontology*, Lawrence, 74 (4): 636-653.

Swen K., Fraaije R. H. B., van der Zwaan G. J., 2001 – Polymorphy and extinction of the Late Cretaceous burrowing shrimp *Protocallianassa faujasi* and first record of the genera *Corallianassa* and *Calliax* (Crustacea, Decapoda, Thalassinoidea) from the Cretaceous. *Contributions to Zoology*, The Hague, 70 (2): 85-98.

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Rodney M. Feldmann, Robin Green & Carrie E. Schweitzer

An unusual Albian (Early Cretaceous) crab from Montana: the earliest eubrachyuran?

Discovery of a single specimen of a unique fossil crab from the Shell Creek Shale in Yellowstone County, Montana, U.S.A., provides evidence that the Eubrachyura de Saint Laurent, 1980, may have appeared in the fossil record earlier than previously thought. The specimen exhibits a plexus of anatomical features typical of both primitive crabs within the Podotremata Guinot, 1977, and the derived forms of the Heterotremata Guinot, 1977, embraced within the Eubrachyura de Saint Laurent, 1980. This combination of morphological features, which has not been recognized previously, suggests that the differentiation of the two major crab groups may have occurred by a series of stages during the latest Early Cretaceous and the early Late Cretaceous.

The specimen was collected along with a second, tiny crab from a sequence of gray and black shale, the Shell Creek Shale, lying between sandy beds of the Muddy Sandstone and the black, siliceous shales of the Mowry Shale (Eicher, 1962), which is known from exposures in central and eastern Montana and in Wyoming as well as in the subsurface of the Bighorn Basin. The Shell Creek Shale has variously been considered a member of the Thermopolis Shale (eg. Moberly, 1960) or as a distinct formation (Eicher, 1960, 1962; Condon, 2000). The Shell Creek Shale was deposited in a deepening-upward basin in which salinity increased stratigraphically upward (Eicher, 1960). Twelve species of foraminiferans have been identified from the formation (Eicher, 1960); however, macrofossils are not common. Those that have been identified include fish scales, turtle fragments, inoceramid bivalves, and ammonites (Eicher, 1960, p. 27). Directly relevant to this study, he also reported that Henry B. Roberts, a prominent worker on fossil decapods, identified two crab species, *Homolopsis* sp. and *Dakoticancer* sp., from localities in northern Bighorn County, Wyoming. Those specimens have not been examined yet to confirm the identification; however, one tiny crab was collected in association with the unusual crab under discussion. This tiny crab may be a homolid and it will be important to determine whether it is conspecific with the specimen Roberts referred to *Homolopsis* sp. Because all of the specimens, other than the two crabs from Montana, are from localities several miles to the southwest, it is difficult to assess the precise environmental setting, but it can be inferred that the crabs inhabited a normal marine habitat on a fine-grained substratum.

The possible eubrachyuran specimen is preserved as a carapace with sternum, maxillipeds, and mandibles in living position. The abdomen and thoracic appendages are absent. It is preserved in a hard, dark matrix and the cuticle is altered to a dark color, reminiscent of iron or manganese oxide. Although most of the matrix is extremely hard, some has oxidized and yields the yellow-orange streak of limonite. The dorsal surface of the carapace is about 28 mm long and 32 mm wide, hexagonal in outline, and weakly vaulted. Regions are moderately well defined and some of them bear large, rimmed pits which may have been the sites of setal hair tufts. The sternum is elongate ovoid, and complete sutures separate sternites 2-3, 3-4, 5-6, 6-7 and 7-8. Sternites 4 and 5 are fused axially and sutured laterally. The posteriormost somites, 7 and 8, are reduced in width and length and are rotated dorsally. Although not present, it appears that pereiopod 4 was reduced in size, relative to the preceeding ones, and that pereiopod 5 was even smaller and was situated dorsally or subdorsally. Superficially, the outline of the sternum and the degree to which sternites are fused is reminiscent of some scyllarid slipper lobsters on one hand and of the dakoticancrid crabs on the other. In either case, the general conformation of the sternum appears to be primitive. However, large orifices, interpreted to be vulvae, are developed near the axis of the sixth abdominal somite – a character typifying the Heterotremata within the Eubrachyura as defined by de Saint Laurent (1980) and adopted by Martin and Davis (2001). Thus, the sternal architecture does not conform to any previously known brachyuran, leading to the conclusion that the specimen represents a new family and genus of crab.

The combination of what are considered primitive and derived characters exhibited by a single individual provides an opportunity for developing alternative evolutionary scenarios. One interpretation would be that the definitional characters separating the Podotremata from the Heterotremata arose in stages, rather than as a single evolutionary event. There is, for example, no compelling reason to argue that the development of a vulva on the 6th sternite must of necessity have evolved simultaneously with other changes in the morphology of the sternum and the conformation of the 4th and 5th pereiopods defining the Heterotremata. This scenario would support the contention that the full array of derived characters arose over a reasonably long period of time and that the specimen at hand simply documents one stage in that transition.

An alternative, and quite different, interpretation would be that this organism represents a relatively early experiment in the evolution of brachyurans – one that did not stand the test of time. Schram (1980, 1983) discussed the concept of *Baupläne*, body plans, in various arthropod and non-arthropod groups. He postulated a morphological landscape based upon presence or absence of essential features, such as uniramous or biramous thoracic appendages, presence or absence of a brood pouch, etc. When arrayed as a morphological landscape, it became clear that several of the *Baupläne* embraced recognizable

clades, some morphological combinations have never been recognized, and some combinations emerged early in the radiation of the clade and were apparently unsuccessful. Applying this scenario, the Albian crab from Montana would have represented an early and failed experiment in the radiation of the Brachyura. Testing these two hypotheses must involve discovery, collection, and study of additional material.

References

Condon S. M., 2000 – Stratigraphic framework of Lower and Upper Cretaceous rocks in central an eastern Montana. *U. S. Geological Survey Digital Data Series*, Washington, DDS57.

Eicher D. L., 1960 – Stratigraphy and micropaleontology of the Thermopolis Shale. *Peabody Museum of Natural History, Yale University, Bulletin*, New Haven Connecticut, 15: 1-126.

Eicher D. L., 1962 – Biostratigraphy of the Thermopolis, Muddy, and Shell Creek formations. *Wyoming Geological Association Guidebook*, Laramie, Wyoming, 17th Annual Field Conference: 72-93.

Guinot D., 1977 – Propositions pour une nouvelle classification des Crustacés Décapodes Brachyoures. *Comptes Rendus des Seances de l'Academie des Sciences, Series 3*, Paris, 285: 1049-1052.

Haan W. de, 1833-1850 – Crustacea. In: *Fauna Japonica sive Description Animalium, quae in Itinere per Japoniam, Jussu et Auspiciis Superiorum, qui Summum in India Batava Imperium Tenent, Suscepto, Annis 1823-1830 Collegit, Notis, Observationibus et Adumbrationibus Illustravit*. P. F. von Siebold & J. Müller (eds.). Lugduni-Batavorum (=Leiden).

Martin J. W. & Davis G. E., 2001 – An updated classification of the Recent Crustacea. *Natural History Museum of Los Angeles County, Science Series*, Los Angeles, 39: 1-124.

Moberly R. Jr., 1960 – Morrison, Cloverly, and Sykes Mountain formation, northern Bighorn Basin, Wyoming and Montana. *Geological Society of America Bulletin*, Boulder, Colorado, 71: 1137-1176.

Saint Laurent M. de, 1980 – Sur la classification et la phylogénie des Crustacés Décapodes Brachyoures. I. Podotremata Guinot, 1977, et Eubrachyura sect. nov. *Comptes Rendus Hebdomadaries des seances de l'Academie des Sciences Série D,* Paris, 290: 1265-1268.

Schram F. R., 1980 – On the Classification of Eumalacostraca. *Journal of Crustacean Biology*, Lawrence, Kansas, 1: 1-10.

Schram F. R., 1983 – Method and madness in phylogeny. In: Crustacean Phylogeny. F. R. Schram (ed.). *A. A. Balkema*, Rotterdam: 331-350.

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Rodney M. Feldmann & Carrie E. Schweitzer

A compilation of Decapoda collections in Museums of the world

Museum collections offer an often underappreciated and untapped source of material that can yield a wealth of information on phylogeny, systematics, paleoecology, paleobiogeography, and evolution (Allmon, 2005). It has been estimated that there is more unpublished material housed in museums than has been described and that this may seriously hinder phylogenetic and statistical analyses of the fossil record (Teichert *et al.*, 1987). Some of the material, especially in older collections, may have been collected from localities that are no longer accessible or that simply no longer exist (i.e., many 19th century localities). Museum collections are unparalleled sources of comparative material, and studying type material is the single best means by which to conduct systematic and phylogenetic studies. Large paleoecological studies are often most efficiently conducted using large museum collections of specimens that were amassed over many years from localities that may yield few specimens on any given day. Thus, it is crucial to evaluate the existing collections of fossil decapod crustaceans and to be cognizant of the location of important type, geographic, and stratigraphic collections.

Locating existing type and other material in museums can be a difficult task. Many museums do not have published catalogs, or if so, they are not on line for access to anyone, anywhere in the world. The location of many important collections of fossil decapod Crustacea has long been unknown, such as most of the material of Hermann von Meyer and Victor Van Straelen. In an effort to locate this and other decapod material, we constructed a questionnaire and sent it to a large number of museums, large and small, that we believed might house collections of fossil decapods. To date, the response has been excellent. We have received responses from 30 institutions. In addition, we compiled information from published catalogues or our own personal research or communication from nine museums for a total of 39 museums in 14 countries on four continents. Unfortunately, most of the von Meyer material has yet to be located, but we have located many collections that have been little known.

Our questionnaire sought the following information: name of museum or institution, curator of decapod or invertebrate collection, address, estimate of number of catalogued specimens of decapods, estimate of number of type specimens of decapods, collections of notable decapod workers, decapod collections from specific areas, ages, or formations, and whether a decapod catalogue was available. We also asked for leads on other museum collections to query. Thus, we continue to seek information on decapod collections, and following, we report the information we have collected thus far. We include some museums for which we received no information but for which a published catalogue exists or for which we possessed information based upon our own research or personal communication. Museums for which information is derived solely from the published catalogue are marked with an asterisk (*), and those for which the information was derived from our own work or personal contacts are marked with a double asterisk (**).

Europe

Austria

Museum: Naturhistorisches Museum in Wien, Geologisch-Paläontologische Abteilung
Curator: Dr. Ortwin Schultz
Address: Burgring 7, 1010 Wien, Austria
Catalogue available?: no
Estimate of number of catalogued decapods: many
Estimate of number of type [and figured] specimens of decapods: many
Collections of notable workers: F. Bachmayer, F. Blaschke, M. F. Glaessner
Collections from a specific area, age, or formation: Jurassic of Austria, many other European localities

France

Museum: Museum national d'Histoire naturelle (Paris)**
Curator: Dr. Jean Paul Saint Martin
Address: Paris 5ème, Jardin des Plantes 2, rue Buffon, Paris, France
Catalogue available?: no, but see Secretan (1964) for Madagascar material
Estimate of number of catalogued decapods: many
Estimate of number of type [and figured] specimens of decapods: many
Collections of notable workers: A. Milne Edwards, S. Secretan, J. M. Remy
Collections from a specific area, age, or formation: France; Jurassic and Cretaceous of Madagascar; Africa

Museum: Musée Vert, Musée d'Histoire naturelle du Mans
Curator: Dr. Nicolas Morel
Address: 204, avenue Jean-Jaurès 72000, Le Mans, France
Catalogue available?: no, but see A. Milne Edwards & Brocchi (1879) and Van Straelen (1936)
Estimate of number of catalogued decapods: at least 20
Estimate of number of type [and figured] specimens of decapods: unknown

Collections of notable workers: a large portion of the collection was lent to the Musée Royal d'Histoire Naturelle de Belgique and was subsequently studied and published by Van Straelen (1936). This material has apparently been lost (N. Morel, personal communication)
Collections from a specific area, age, or formation: Cenomanian stratotype of Le Mans, France

Museum: Observatoire des Sciences de l'Univers de Grenoble (OSUG), Université Joseph Fourier
Curator: Dr. Emmanuel Robert
Address: Institut Dolomieu, 15, rue Maurice Gignoux, 38031 Grenoble cedex, France
Catalogue available?: yes
Estimate of number of catalogued decapods: about 32
Estimate of number of type [and figured] specimens of decapods: 3 holotypes
Collections of notable workers: V. Van Straelen
Collections from a specific area, age, or formation: Jurassic and Cretaceous of France

Museum: Museum d'Histoire Naturelle de Nantes
Curator: Dr. Serge Regnault
Address: MHNN 12, rue Voltaire, 44000 Nantes, France
Catalogue available?: no
Estimate of number of catalogued decapods: none given
Estimate of number of type [and figured] specimens of decapods: 1 holotype
Collections of notable workers: none given
Collections from a specific area, age, or formation: none given

Museum: Collections de Géologie, Université Claude Bernard Lyon
Curator: Dr. Abel Prieur (Directeur des Collections de Géologie)
Address: Université Claude Bernard Lyon, CNRS UMR 5125 PEPS, Paléoenvironments et Paléobiosphère, Bâtiment Géode, 2, rue Dubois, 69622 Villeurbanne Cedex, France
Catalogue available?: no
Estimate of number of catalogued decapods: about 6
Estimate of number of type [and figured] specimens of decapods: 1 holotype, 1 paratype
Collections of notable workers: J. P. Saint Martin & P. Müller (1988)
Collections from a specific area, age, or formation: Miocene of Algeria

Museum: Collection de l'Ecole des Mines de Paris depose à Lyon
Catalogue available?: no
Estimate of number of catalogued decapods: about 4
Estimate of number of type [and figured] specimens of decapods: 3 holotypes, 1 paratype
Collections of notable workers: V. Van Straelen, A. Oppel
Collections from a specific area, age, or formation: Jurassic and Cretaceous of France

Museum: Service de Valorisation des Collections de Géologie (SERVACO-Géol), Université de Bourgogne
Curator: Dr. Jérôme Thomas
Address: SERVACO-Géol, UMR uB-CNRS 5561 Biogéosciences, UFR des Sciences de la Terre, 6, boulevard Gabriel, 21000 Dijon, France
Catalogue available?: http://transtyfipal.u-bourgogne.fr
Estimate of number of catalogued decapods: unknown
Estimate of number of type [and figured] specimens of decapods: 1 in University of Burgundy
Collections of notable workers: none
Collections from a specific area, age, or formation: none

Germany

Museum: Bavarian State Collection for Palaeontology and Geology (Bayerische Staatsammlung für Paläontologie und historische Geologie)
Curator: Dr. Martin Nose
Address: Richard-Wagner-Straße 10, D-80333 München, Germany
Catalogue available: not yet
Estimate of number of catalogued decapods: 1,500-2,000 (preliminary)
Estimate of number of type [and figured] specimens of decapods: 300-500 (preliminary)
Collections of notable workers: R. Förster, W. Moericke, G. G. zu Münster, C. A. Oppel, G. Wehner
Collections from a specific area, age, or formation: Upper Jurassic of Solnhofen and Eichstätt

Museum: Forschungsinstitut Senckenberg
Curator: Dr. Alan Lord and Claudia Franz (Technical Assistant)
Address: Sektion Mikropalaeontologie I, Forschungsinstitut Senckenberg, Senckenberganlage 25, 60325 Frankfurt am Main, Germany
Catalogue available?: yes, but not yet complete
Estimate of number of catalogued decapods: about 1,000 specimens
Estimate of number of type [and figured] specimens of decapods: 1 holotype and published material of M. Glaessner, H. Malz, O. Kuhn, K. A. Frickinger, V. Van Straelen, H. von Meyer
Collections of notable workers: H. von Meyer, H. Malz
Collections from a specific area, age, or formation: Jurassic (Solnhofen-type limestones) of Germany

Museum: Museum für Naturkunde Berlin, Paläontologisches Museum, Humboldt-Universität zu Berlin**
Curator: Dr. Christian Neumann
Address: Museum für Naturkunde, der Humboldt-Universität zu Berlin, Invalidenstrasse 43, D-10115 Berlin, Germany
Catalogue available?: no
Estimate of number of catalogued decapods: unknown, at least 100
Estimate of number of type [and figured] specimens of decapods: 51 holotypes and figured specimens (recorded by RMF and CES, June, 2001)
Collections of notable workers: A. Bittner, A. Desmarest, O. Fraas, H. von Meyer, G. G. zu Münster, F. Noetling, E. F. von Schlotheim
Collections from a specific area, age, or formation: Jurassic (Solnhofen-type limestones) of Germany; Eocene of Italy (Bittner)

Museum: Staatliches Museum für Naturkunde Stuttgart
Curator: Dr. Günter Schweigert (Triassic), Dr. Gert Dietl (Jurassic), Dr. Michael W. Rasser (Cenozoic)
Address: Staatliches Museum für Naturkunde, Rosenstein 1, 70191 Stuttgart, Germany
Catalogue available: no
Estimate of number of catalogued decapods: unknown
Estimate of number of type [and figured] specimens of decapods: about 40 holotypes
Collections of notable workers: O. Fraas collection; R. Mundlos collection
Collections from a specific area, age, or formation: Triassic and Jurassic of SW Germany, especially lithographic limestones of Solnhofen and Nusplingen; Eocene of northern Germany (Helmstedt) and Egypt; Cretaceous of Lebanon

Hungary

Museum: Földtani Intézet (Geological Survey)**
Curator: Dr. Pál Müller
Address: Stefánia út 14, H-1143 Budapest, Hungary
Catalogue available: contact Dr. Pál Müller
Estimate of number of catalogued decapods: 370
Estimate of number of type [and figured] specimens of decapods: 33 holotypes
Collections of notable workers: E. Lőrenthey
Collections from a specific area, age, or formation: Cenozoic of Hungary

Museum: Természettudományi Múzeum Földés Őslénytár (Natural History Museum of Hungary)**
Curator: Dr. Pál Müller
Address: contact Dr. Pál Müller at Stefánia út 14 H-1143 Budapest Hungary
Catalogue available?: contact Pál Müller
Estimate of number of catalogued decapods: 560 catalogued Miocene, about 800 Eocene
Estimate of number of type [and figured] specimens of decapods: at least 11 Miocene holotypes, about 88 Eocene holotypes
Estimate of number of uncatalogued decapods: types and other material from Müller (1974) are not yet catalogued and are in two separate boxes in a large, low drawer.
Collections of notable workers: P. Müller
Collections from a specific area, age, or formation: Cenozoic of Hungary

Italy

Museum: Museo Civico di Storia Naturale di Milano
Curator: Dr. Alessandro Garassino, Dr. Giorgio Teruzzi
Address: Corso Venezia, 55, 20121 Milano, Italy
Catalogue available?: see De Angeli & Garassino (2006)
Estimate of number of catalogued decapods: 2,680
Estimate of number of type [and figured] specimens of decapods: 49 holotypes, 125 patypes and 187 figured
Collections of notable workers: A. Garassino, G. Teruzzi
Collections from a specific area, age, or formation: Mesozoic of Italy, Lebanon, and Madagascar

Museum: Museo Civico "G. Zannato" di Montecchio Maggiore (Vicenza)
Curator: Dr. Viviana Frisone
Address: P. le Marconi 15, I-36075 Montecchio Maggiore (Vicenza), Italy
Catalogue available: yes
Estimate of number of catalogued decapods: 1,450
Estimate of number of type [and figured] specimens of decapods: about 63 holotypes, about 242 paratypes
Collections of notable workers: C. Beschin, A. Busulini, A. De Angeli, G. Tessier
Collections from a specific area, age, or formation: Cenozoic of Italy

Museum: Museo Civico D. Dal Lago
Curator: Dr. Bernardetta Pallozzi, Dr. Dario Savi
Address: Palazzo Festari, Corso Italia 63, 36078 Valdagno, (Vicenza), Italy
Catalogue available?: yes
Estimate of number of catalogued decapods: 16
Estimate of number of type [and figured] specimens of decapods: 2 paratypes
Collections of notable workers: none
Collections from a specific area, age, or formation: middle Eocene of the localities Grola Cave and Monte di Malo, near Vicenza, Italy

Museum: Museo del Dipartimento per lo Studio del Territorio e delle sue Risorse, Università di Genova
Curator: Dr. Maria Cristina Bonci
Address: Dip.Te.Ris., Università di Genova, Corso Europa 26, 16132 Genova, Italy
Catalogue available?: see De Angeli & Garassino (2006)
Estimate of number of catalogued decapods: 5
Estimate of number of type [and figured] specimens of decapods: 3 holotypes
Collections of notable workers: none
Collections from a specific area, age, or formation: Perrando Collections – Sassello (Savona, Liguria, Italia settentrionale) - Oligocene - Tertiary Piedmont Basin, Molare Formation

Museum: Museo di Storia Naturale dell'Università, degli Studi di Firenze, Sezione di Geologia e Paleontologia
Curator: Dr. Laura Delle Cave
Address: Museo di Storia Naturale dell'Università, degli Studi di Firenze, Sezione di Geologia e Paleontologia, Via G. La Pira, 4, 50121 Firenze, Italy
Catalogue available?: see Delle Cave (1981)
Estimate of number of catalogued decapods: unknown
Estimate of number of type [and figured] specimens of decapods: 22 holotypes, some of which may be lost
Collections of notable workers: G. Checchia-Rispoli, G. Ristori
Collections from a specific area, age, or formation: Neogene of Italy

Museum: Museo del Dipartimento di Geologia, Paleontologia e Geofisica dell'Università di Padova
Curator: Dr. Mariagabriella Fornasiero
Address: Museo del Dipartimento di Geologia, Paleontologia e Geofisica dell'Università di Padova, Via Giotto, 1-35137 Padova, Italy
Catalogue available?: yes

Estimate of number of catalogued decapods: 240
Estimate of number of type [and figured] specimens of decapods: 11 holotypes, 4 figured
Collections of notable workers: R. Fabiani, S. Secretan
Collections from a specific area, age, or formation: Eocene of Italy

The Netherlands

Museum: Oertijdmuseum De Groene Poort
Curator: Dr. René H. B. Fraaije
Address: Bosscheweg 80, 5283 WB Boxtel, The Netherlands
Catalogue available?: not yet
Estimate of number of catalogued decapods: 2,500
Estimate of number of type [and figured] specimens of decapods: 30 holotypes
Collections of notable workers: R. H. B Fraaije, B. van Bakel
Collections from a specific area, age, or formation: type Maastrichtian, Cenozoic of western Europe, Late Jurassic of southern Germany and UK

Poland

Museum: Institute of Paleobiology, Polish Academy of Sciences
Curator: Dr. Maria Aleksandra Bitner
Address: Institute of Paleobiology, ul. Twarda 51/55, 00-818, Warszawa, Poland
Catalogue available?: yes
Estimate of number of catalogued decapods: about 300 and about 100 uncatalogued specimens
Estimate of number of type [and figured] specimens of decapods: 2 holotypes
Collections of notable workers: A. Gaździcki
Collections from a specific area, age, or formation: Miocene Cape Melville Formation, King George Island, Antarctica; Eocene La Meseta Formation, Seymour Island, Antarctica; Upper Jurassic of Poland

Switzerland

Museum: Musée Cantonal de Géologie, Lausanne
Curator: Dr. Robin Marchant
Address: UNIL-Anthropole, CH-1015 Lausanne, Switzerland
Catalogue available?: see Septfontaine (1995). PDF available at www.unil.ch/webdav/site/mcg/shared/Types_Paleonto_MGL.pdf
Estimate of number of catalogued decapods: 50
Estimate of number of type [and figured] specimens of decapods: 8 holotypes
Collections of notable workers: M. de Tribolet
Collections from a specific area, age, or formation: Swiss Jurassic

Museum: Muséum d'Histoire Naturelle de la Ville de Genève
Curator: Dr. Lionel Cavin
Address: Département de Géologie et Paléontologie, Muséum d'Histoire Naturelle de la Ville de Genève, CP 6434 1211 Geneve 6, Switzerland
Catalogue available?: in part, A. Favre collection is published (Benier & Berset, 1989)
Estimate of number of catalogued decapods: 50
Estimate of number of type [and figured] specimens of decapods: 1 figured
Collections of notable workers: V. Van Straelen
Collections from a specific area, age, or formation: Cretaceous of France and UK, Jurassic of Germany

United Kingdom

Museum: National Museums of Scotland, Edinburgh
Curator: Dr. Lyall I. Anderson
Address: Department of Natural Sciences, National Museums of Scotland, Building 8, West Granton Centre, 242, West Granton Road, Edinburgh, EH5 1JA Scotland, UK
Catalogue available?: yes but not available over the internet yet
Estimate of number of catalogued decapods: 98
Estimate of number of type [and figured] specimens of decapods: none
Collections of notable workers: A. Copland Hutchison
Collections from a specific area, age, or formation: Solnhofen (Jurassic) of Germany; Gault Clay (Cretaceous) of Folkestone, Kent, England; London Clay (Eocene) of London, England and the Isle of Sheppey

Museum: The Natural History Museum (London)
Curator: Dr. Andrew Ross
Address: Department of Palaeontology, The Natural History Museum, Cromwell Road, S. Kensington, SW7 5BD London, UK
Catalogue available?: see Morris (1980)
Estimate of number of catalogued decapods: 6,000
Estimate of number of type [and figured] specimens of decapods: 500 holotypes
Collections of notable workers: T. Bell, J. S. H. Collins, S. F. Morris, T. H. Withers, H. Woods, H. Woodward, C. W. Wright
Collections from a specific area, age, or formation: Jurassic, Cretaceous, and Eocene of UK; many former British colonies and protectorates

Museum: Sedgwick Museum of Earth Sciences
Curator: Dr. Liz Harper (Honoree Curator), Dan Pemberton (Collections Manager), Mathew Lowe (Collections Assistant)
Address: Sedgwick Museum of Earth Sciences, University of Cambridge, Downing Street, CB2 3EQ Cambridge, UK
Catalogue available?: yes
Estimate of number of catalogued decapods: 1,218
Estimate of number of type [and figured] specimens of decapods: 54 syntypes, 19 holotypes, 4 metatypes, 150 figured
Collections of notable workers: T. Bell, Carter, G. Mantell, C. W. Wright
Collections from a specific area, age, or formation: Cretaceous and Cenozoic of Britain

Museum: University Museum of Natural History (Oxford)
Curator: Dr. Erik Seiffert
Address: Parks Road, OX1 3PW Oxford, UK

Catalogue available?: http://www.oum.ox.ac.uk/collect/geology2.htm
Estimate of number of catalogued decapods: about 1,000
Estimate of number of type [and figured] specimens of decapods: 35 holotypes
Collections of notable workers: T. Bell, J. S. H. Collins, J. Phillips, W. J. and S. Quayle
Collections from a specific area, age, or formation: Jurassic, Cretaceous, and Eocene of UK; Cretaceous of France

Asia

Japan

Museum: Mizunami Fossil Museum
Curator: Dr. Hiroaki Karasawa
Address: Yamanouchi, Akeyo, Mizunami, Gifu 509-6132, Japan
Catalogue available?: http://www2.city.mizunami.gifu.jp/mizunami/dbtop_e.html
Estimate of number of catalogued decapods: 633
Estimate of number of type [and figured] specimens of decapods: 76 holotypes, 91 paratypes
Collections of notable workers: H. Karasawa
Collections from a specific area, age, or formation: all areas of Japan

Museum: Natural History Museum and Institute, Chiba
Curator: Dr. Hisayoshi Kato
Address: 955-2 Aoba-cho, Chuo-ku, Chiba 260-8682, Japan
Catalogue available?: yes
Estimate of number of catalogued decapods: 1,500
Estimate of number of type [and figured] specimens of decapods: 1 holotype, 17 paratypes
Collections of notable workers: H. Kato
Collections from a specific area, age, or formation: northeastern Japan

Synopsis of other Japanese Museums (from H. Kato):
Tohoku University Museum, Institute of Geology and Paleontology, Sendai: 800 numbered specimens, of which about 50 are holotypes or figured specimens of R. Imaizumi or H. Kato
Hokkaido University Museum: 20 holotypes and figured specimens of T. Nagao
National Science Museum: about 40 specimens of which 6 are holotypes or figured specimens of M. Takeda and I. Fujiyama
Saitama Museum of Natural History: 200 specimens from Miocene Chichibu Basin
Gunma Museum of Natural History: about 50 specimens including 2 patypes, 23 figured
Kanagawa Museum of Natural History: about 200 specimens including 1 holotype, 1 paratype, 23 figured

North America

Mexico

Museum: Colecion Nacional de Paleontologia, Instituto de Geologia, UNAM
Curator: Dr. Maria del Carmen Perrilliat
Address: Instituto de Geologia, UNAM, Ciudad Universitaria, Coyoacan, Mexico DF 04510, Mexico
Catalogue available?: yes
Estimate of number of catalogued decapods: 150
Estimate of number of type [and figured] specimens of decapods: 10 holotypes, 30 paratypes
Collections of notable workers: F. J. Vega
Collections from a specific area, age, or formation: Cretaceous and Paleocene of northeastern Mexico

United States of America

Museum: Carnegie Museum of Natural History**
Curator: Albert Kollar (Collections Manager)
Address: Section of Invertebrate Paleontology, Carnegie Museum of Natural History, 4400 Forbes Avenue, Pittsburgh, Pennsylvania 15213 USA
Catalogue available?: yes
Estimate of number of catalogued decapods: about 600
Estimate of number of type [and figured] specimens of decapods: 11 holotypes, 23 paratypes
Collections of notable workers: R. M. Feldmann, C. E. Schweitzer, F. J. Vega
Collections from a specific area, age, or formation: Jurassic Solnhofen-type limestones of Germany; Eocene of Britain; Eocene Castle Hayne Formation of north Carolina, USA; Cretaceous of Western Interior north America; Paleogene of Washington, USA; Cretaceous and Eocene of Latin America

Museum: The Field Museum
Curator: Dr. Scott Lidgard (Associate Curator, Fossil Invertebrates), Dr. Peter Wagner (Associate Curator, Fossil Invertebrates)
Address: Department of Geology, The Field Museum, 1400 S. Lake Shore Drive, Chicago, IL 60605 USA
Catalogue available?: no
Estimate of number of catalogued decapods: 466 lots
Estimate of number of type [and figured] specimens of decapods: 254 lots
Collections of notable workers: none
Collections from a specific area, age, or formation: Jurassic Solnhofen of Germany, Eocene Green River Formation of western USA

Museum: Museum of Comparative Zoology, Harvard University*
Curator: Dr. Fred Collier
Address: Museum of Comparative Zoology, Harvard University, 26 Oxford Street, Cambridge, MA 02138-2902, USA
Catalogue available?: see Rolfe (1963)
Estimate of number of catalogued decapods: about 39
Estimate of number of type [and figured] specimens of decapods: 2 holotypes, 1 paratype, 3 syntypes, 3 figured
Collections of notable workers: W. Stimpson, A. F. Eser
Collections from a specific area, age, or formation: Germany (see Rolfe, 1963)

Museum: Peabody Museum of Natural History*
Curator: Dr. Susan Butts (Senior Collections Manager)
Address: Yale University, New Haven, CT 06520-8118, USA

Catalogue available?: see White (1996)
Estimate of number of catalogued decapods: about 119
Estimate of number of type [and figured] specimens of decapods: 3 holotypes, 1 paratype
Collections of notable workers: M. J. Rathbun, H. B. Roberts
Collections from a specific area, age, or formation: Cretaceous and Cenozoic of Pacific north America; Cretaceous of east coastal USA; Jurassic Solnhofen-type limestones of Germany

Museum: San Diego Natural History Museum
Curator: Dr. Scott Rugh (Collections Manager Invertebrate Fossils)
Address: P. O. Box 121390, San Diego, California 92112-1390 USA
Catalogue available?: yes
Estimate of number of catalogued decapods: 1,213 records representing 10,466 specimens
Estimate of number of type [and figured] specimens of decapods: 85 holotypes
Collections of notable workers: G. A. Bishop, M. J. Rathbun, C. E. Schweitzer, and R. M. Feldmann
Collections from a specific area, age, or formation: Cretaceous and Cenozoic of Pacific north America

Museum: United States National Museum of Natural History, Smithsonian Institution**
Curator: Warren C. Blow (Museum Specialist)
Address: Department of Paleobiology, National Museum of Natural History, P. O. Box 37012, NHB, MRC121, Washington, D.C. 20013-7012 USA
Catalogue available?: yes
Estimate of number of catalogued decapods: unknown
Estimate of number of type [and figured] specimens of decapods: many
Collections of notable workers: G. A. Bishop, W. C. Blow, R. M. Feldmann, M. J. Rathbun, C. E. Schweitzer, H. B. Stenzel, A. B. Tucker
Collections from a specific area, age, or formation: north America, central America, Cretaceous and Cenozoic of Pacific north America

Oceania

Australia

Museum: Museum Victoria
Curator: Dr. David Holloway
Address: GPO Box 666, Melbourne, Victoria 3001, Australia
Catalogue available?: printed catalogue
Estimate of number of catalogued decapods: 340
Estimate of number of type [and figured] specimens of decapods: 8 holotypes, 14 figured
Collections of notable workers: R. J. F. Jenkins, F. A. Cudmore
Collections from a specific area, age, or formation: Cenozoic of southern Australia; Jurassic Solnhofen of Germany; Cretaceous of southern UK

New Zealand

Museum: Paleontology Collection, University of Auckland
Curator: Dr. Neville Hudson
Address: School of Geography, Geology and Environmental Science (SGGES), University of Auckland, Private Bag 92019, Auckland Mail Centre, Auckland 1142, New Zealand
Catalogue available?: yes
Estimate of number of catalogued decapods: 250-500
Estimate of number of type [and figured] specimens of decapods: 2 holotypes
Collections of notable workers: none
Collections from a specific area, age, or formation: Paleogene and Neogene of New Zealand

References

Allmon W. D., 2005 – The importance of museum collections in paleobiology. *Paleobiology*, Lawrence, Kansas, 31: 1-5.

De Angeli A. & Garassino A., 2006 – Catalog and Bibliography of the fossil Stomatopoda and Decapoda from Italy. *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 35 (1): 1-95.

Benier C. & Berset S., 1989 – Les collections du Departement de Géologie et de Paléontologie des Invertebres du Museum d'Histoire Naturelle de Genève. 35. La Collection A. Favre (Cephalopoda, Trilobita, Decapoda, Cirripedia). *Revue de Paléobiologie*, Geneva, vol. spec. no. 3: 115-142.

Delle Cave L., 1981 – Catalogue of type specimens in the Invertebrate Palaeontological Collections of the Museum of Geology and Palaeontology of the University of Florence. (Italy). Crustacea, Decapoda. *Atti della Società Toscana di Scienze Naturali, Memorie*, Pisa, Serie A, 88: 43-50.

Milne Edwards A. & Brocchi P., 1879 – Note sur quelques Crustacés fossils appartenant au groupe des Macrophthalmiens. *Bulletin de la Société Philomathique de Paris*, Paris, 7 (3): 113-117.

Morris S. F., 1980 – Catalogue of the Type and Figured specimens of fossil Crustacea (excl. Ostracoda), Chelicerata, Myriapoda and Pycnogonida in the British Museum (Natural History). *British Museum* (*Natural History*), London.

Müller P., 1974 – Decapoda (Crustacea) fauna a budapesti miocénből (2). *Földtani Közlöny*, Budapest, 104 (1): 275-287.

Rolfe W. D. I., 1963 – Catalogue of type specimens in the invertebrate paleontological collections of the Museum of Comparative Zoology. Arthropoda. *Bulletin of the Museum of Comparative Zoology at Harvard College*, Cambridge, Massachusetts, 129 (7): 369-398.

Saint Martin J.-P. & Müller P., 1988 – Les Crustacés Décapodes du Messinien récifal d'Oranie (Algérie). *Geobios*, Lyon, 21 (2): 251-257.

Secretan S., 1964 – Les Crustacés Décapodes du Jurassique supérieur et du Crétacé de Madagascar. *Mémoires du Muséum National d'Histoire Naturelle*, Série C, Sciences de la Terre, Paris, 14: 1-223.

Septfontaine M., 1995 – Catalogue des types paléontologiques deposes au Musée cantonal de Géologie, Lausanne. *Mémoires de Géologie*, Lausanne, 26: 1-78.

Teichert C., Sweet W. C & Boucot A. J., 1987 – The unpublished fossil record: implications. *Senckenbergiana Lethaea*, Frankfurt am Main, 68 (1/4): 1-19.

Van Straelen V., 1936 – Crustacés Décapodes nouveaux ou peu connus de l'époque Crétacique. *Musée Royal d'Histoire Naturelle de Belgique*, Brussels, 12 (45): 1-40.

White R. D., 1996 – A type catalog of fossil invertebrates (Arthropoda: Crustacea) in the Yale Peabody Museum. *Postilla*, New Haven, Connecticut, 210: 1-19.

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Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano
Volume XXXV – Fascicolo II

René H. B. Fraaije, Barry W. M. Van Bakel & John W. M. Jagt

A new species of *Goniocypoda* and the first record of *Glyphithyreus wetherelli* (Bell, 1858) (Decapoda, Brachyura) from the Eocene of Nieuwvliet-Bad, The Netherlands

The beaches at Nieuwvliet-Bad and Cadzand in the province of Zeeland (The Netherlands) and at Knokke (northwest Belgium) are renowned for the Cenozoic fossil assemblages (mostly vertebrate and molluscan remains, but also echinoderms and crabs) that are washed ashore there. Just offshore, strata of late Eocene, early-middle Oligocene and late Miocene age crop out, and through periodic storms and daily tides fossils from these levels are eroded loose and washed ashore. The result is a near-constant supply of new material, in particular numerous shark teeth and molluscan shells (Lindemann & Fraaije, 2003). During the 1980s and 1990s, deeper-lying Cenozoic sands were used as supplementary material for beach protection in this area, notably at Knokke and Cadzand. This resulted in an admixture of fossils from those sands and from autochthonous strata offshore. Phosphatic internal moulds of decapod crustaceans, mostly crabs, are not uncommon in this beach material. Until now, only two species of crab, *Coeloma* (*C.*) *balticum* and *Harpactocarcinus* sp. (= *Eocarpilius* sp., as interpreted herein) were recorded (Fraaye, 1998; Fraaije, 2003) from those localities, but these occur in comparatively large numbers, and are sought-after objects for collectors. The present record of a new species of *Goniocypoda* adds to the list of post-Paleocene decapod crustaceans currently known from Dutch territory (Tab. 1).

Systematic palaeontology

For higher-level classification of decapod crustaceans, we follow Martin & Davis (2001).

Superfamily Xanthoidea MacLeay, 1838
Family Hexapodidae Miers, 1886
Genus *Goniocypoda* H. Woodward, 1867

Type species: *Goniocypoda edwardsi* H. Woodward, 1867, by monotypy.

Stratigraphic range: ?Latest Cretaceous (Maastrichtian); Paleocene-Eocene (see Schweitzer & Feldmann, 2001; Schweitzer, 2005; Guinot, 2006).

Goniocypoda verheyeni n. sp.

Diagnosis: carapace small, subrectangular in outline, much wider than long; carapace regions poorly marked; very wide orbitofrontal margin; posterior margin nearly straight; large hook-shaped epimeral muscle scars; two nodes at base of rostrum.

Derivation of name: in honour of Ivo Verheyen (Moergestel, the Netherlands), who collected and donated the type, and sole specimen known to date.

Material: the holotype, a phosphatic internal mould, is MAB k.2440, in the collections of Oertijdmuseum De Groene Poort, Boxtel (the Netherlands).

Type locality: beach between Nieuwvliet-Bad and Cadzand, province of Zeeland (the Netherlands), close to radar and nature reserve 'de Zwarte Polder' (Riemslag, 2003, figs. 3, 5).

Description. Carapace subrectangular in outline (Figs. 1-4), length/width (L/W) ratio 1:1.75, widest about halfway from front. Orbitofrontal margin about two-thirds of maximum carapace width. Orbits rectangular, about three times longer than wide. Wide base of the rostrum covered with two nodes; rostrum itself not preserved. Short convex anterolateral margins curving into straight, subparallel posterolateral margins. Posterior margin straight, slightly sinuous in central part. Regions of carapace very poorly defined. Deep, almost subcircular epimeral adductor muscle scars extending into the cervical furrow anteriorly and into a short branchiocardiac furrow laterally, forming two typical hook-shaped depressions. Cervical furrow directed towards widest part of anterolateral margin. First thoracic sternite lacking, sternites 2 to 4 are fused; sternites 5, 6 and 7 almost identical in shape and size, sutures slightly convex posteriorly; seventh sternite barely visible from ventral side. Abdomen missing; abdominal cavity extending almost to buccal cavity.

Discussion. So far, the genus *Goniocypoda* contained nine or ten recorded species (Crane, 1981; Crane & Quayle, 1986; Schweitzer & Feldmann, 2001). In general appearance, *G. verheyeni* n. sp. seems most closely related to the type species, *G. edwardsi*, from the middle Eocene ('Bartonian'; H. Woodward, 1867, p. 2, pl. 21, fig. 1) of High Cliff, Hamsphire (England), to *G. collinsi* Crane & Quayle, 1986 (p. 101, pl. 1, fig. 1) from the middle Eocene Bracklesham Beds (Lutetian) of Brook, Hampshire, and to *G. elmorensis* Crane & Quayle, 1986 (p. 103, pl. 1, figs. 3, 4) from ?unit 7 of the Elmore Formation (Bracklesham Group, middle Eocene) of Hampshire. The new species differs from the first-named in having

Table 1 - List of post-Paleocene decapod crustaceans currently known from Dutch territory, compiled from literature data and personal observations.

EOCENE	*Coeloma* (*Coeloma*) *balticum* Schlüter, 1879	Fraaye (1998)	Nieuwvliet-Bad, Breskens, Ootmarsum
	Coeloma? sp.	Spaink (1978)	Losser
	Eocarpilius sp.	Fraaye (1998, as *Harpactocarcinus* sp.)	Cadzand, Nieuwvliet-Bad
	Glyphithyreus wetherelli (Bell, 1858)	herein	Nieuwvliet-Bad
	Goniocypoda verheyeni n. sp.	herein	Nieuwvliet-Bad
OLIGOCENE	*Ciliopagurus obesus* van Bakel *et al.*, 2003	herein	De Kaloot
	Coeloma (*Paracoeloma*) *rupeliense* Stainier, 1887	herein	Cadzand, Nieuwvliet-Bad, Bruine Bank (north Sea), Mill
	Coeloma (*Coeloma*) *balticum* Schlüter, 1879	Posthumus (1923); De Neve (1945)	Twente
	Homarus percyi van Beneden, 1872	herein	Breskens
	Laeviranina hollandica Collins *et al.*, 1997	Collins *et al.* (1997)	Winterswijk-Miste
MIOCENE	*Cancer parvidens* Collins & Fraaye, 1991	Collins & Fraaye (1991)	Liessel
	Cancer sp.	herein	Bemmel
	Coeloma sp.	herein	Bemmel
	Dromia sp.	herein	Bemmel
	Pagurus sp.	Jagt *et al.* (2006)	Liessel
	Maja squinado (Herbst, 1788)	herein	Liessel
	Tasadia carniolica (Bittner, 1884)	Holthuis (1949, as *Cancer deshayesi* A. Milne-Edwards), Janssen & Müller (1984)	Winterswijk-Miste, Beringen, Peel district
PLIOCENE	*Anapagurus laevis* (Bell, 1845)	Holthuis (1949)	western Scheldt
	Axius sp.	herein	Mill
	Callianassa subterranea (Montagu, 1808)	herein	Mill
	Cancer pagurus von Linné, 1758	herein	Mill, Balgoy
	Corystidae sp. 1	herein	Mill
	Corystidae sp. 2	herein	Mill
	Ebalia cranchii Leach, 1817	Bloklander (1953)	Ellewoutsdijk
	Ebalia cf. *tumefacta* (Montagu, 1808)	herein	Mill
	Liocarcinus holsatus (Fabricius, 1798)	herein	De Kaloot, Balgoy, Mill
	Maja squinado (Herbst, 1788)	Holthuis (1949)	Biggekerke, Vlissingen, Bergen op Zoom, De Kaloot
	Pagurus cf. *bernhardus* (von Linné, 1758)	herein	Mill
	Portunus sp.	Holthuis (1949)	Vlissingen, Bergen op Zoom
PLEISTOCENE	*Cancer pagurus* von Linné, 1758	Holthuis (1949)	Dongen, Prinsenheuvel, Roosendaal, Dordrecht (boreholes), western Scheldt
	Carcinus maenas (von Linné, 1758)	Holthuis (1949)	Lienden, Prinsenheuvel, Dordrecht, Hardenhoek, 's Gravendeel, Roosendaal
	Liocarcinus holsatus (Fabricius, 1798)	Holthuis (1949)	's Gravendeel, Moerdijk
	Maja squinado (Herbst, 1788)	Holthuis (1949)	Schouwen
	Pagurus bernhardus (von Linné, 1758)	Holthuis (1949)	Ginneken, Maassluis, Roosendaal, Dordrecht (boreholes)
HOLOCENE	*Carcinus maenas* (von Linné, 1758)	Holthuis (1949)	Wieringermeer, Bergen, Velzeroord, Driehuis-Velzen, Bergen op Zoom
	Liocarcinus holsatus (Fabricius, 1798)	Holthuis (1949)	Bergen, Haamstede

a L/W ratio of 1:1.75, rather than 1:1.4-1.6 (see Tab. 2), and in showing a more pronounced epimeral muscle scar-cervical furrow system, plus in showing two nodes at the base of the rostrum.

Goniocypoda collinsi differs from *G. verheyeni* n. sp. in having a much smaller L/W ratio (1:1.4) as well as in showing more convex lateral margins and a shallower and less extensive epimeral muscle scar-cervical furrow system, while *G. elmorensis* can be distinguished from the new taxon by displaying a ridge on the orbitofrontal margin and three tubercles (on the internal mould) around the epibranchial furrow, as well as in having a smaller L/W ratio (1.6-1.7, but based on estimated measurements; see Crane & Quayle, 1986, p. 104).

Goniocypoda verheyeni n. sp. is distinguished from all other known species of the genus by its high L/W ratio (see Tab. 2) and by the combined features of relatively large, hook-shaped epimeral muscle scars extending into

Table 2 - L/W ratios of all species of *Goniocypoda* known to date. Data from Carter (1898), Remy & Tessier (1954), Bittner (1893), Glaessner (1933), Glaessner & Rao (1960), Plaziat & Secretan (1971), H. Woodward (1867), Crane (1981), Crane & Quayle (1986), Schweitzer & Feldmann (2001), Schweitzer *et al.* (2004) and Guinot (2006).

G. audensis Plaziat & Secretan, 1971 (lower Eocene; France)	1:1.5
G. collinsi Crane & Quayle, 1986 (middle Eocene; England)	1:1.4
G. edwardsi H. Woodward, 1867 (middle Eocene; England)	1:1.4-1.6
G. elmorensis Crane & Quayle, 1986 (middle Eocene; England)	1:1.6-1.7
G. quaylei Crane, 1981 (middle Eocene; England)	1:1.5-1.6
G. rajasthanica Glaessner & Rao, 1960 (upper Paleocene-lower Eocene; India)	1:1.0-1.5
G. sindensis Glaessner, 1933 (Eocene; Pakistan)	1:1.3
G.? sulcata Carter, 1898 (middle Cretaceous; England)	1:1.4
G.? tessieri Remy & Tessier, 1954 (Maastrichtian; Senegal)	1:1.2-1.4
G. transsilvanica Bittner, 1893 (Eocene; Romania, Egypt)	1:1.5
G. verheyeni n. sp. (middle-upper Eocene; The Netherlands)	1:1.75

a straight cervical furrow, of two nodes at the base of the rostrum, of a curved anterolateral margin extending into a straight posterolateral margin, and of curved sternal sutures.

A comparison of all species of *Goniocypoda* on record to date (Tab. 2) would suggest an increase in carapace width with stratigraphic time, concomitant with a northerly dispersal and several immigration events. Details of these need to be unravelled; this is beyond the scope of the present paper.

Family Panopeidae Ortmann, 1893
Subfamily Eucratopsinae Stimpson, 1871
Genus *Glyphithyreus* Reuss, 1859

Type species: *Plagiolophus wetherelli* Bell, 1858 = *Glyphithyreus affinis* Reuss, 1859, by monotypy, under ICZN 1999, Article 67.8.

Glyphithyreus wetherelli (Bell, 1858)

Material: a single phosphatic internal mould (MAB k.2450) (Fig. 8), collected by Mark Bosselaers (Berchem, Belgium).

Locality: beach between Nieuwvliet-Bad and Cadzand.

Discussion. After the thorough revision by Karasawa & Schweitzer (2004), the genus *Glyphithyreus* is confined to four species of (?Late Cretaceous)-Paleocene and Eocene age, placement of *Plagiolophus sulcatus* (Beurlen, 1939) in *Glyphithyreus* being tentative. The commonest and most widely distributed member of the genus is *G. wetherelli*, with records from the Paleocene of Punjab and Baluchistan (Pakistan; Collins & Morris, 1978) and Eocene of northern Germany, southern England, Belgium, France, Spain and Senegal (Remy & Tessier, 1954; Plaziat & Secretan, 1971; Moths & Montag, 2002). Ilyin (2005, pp. 72, 241, pl. 11, figs. 4, 5) recorded *G.* cf. *wetherelli* from the lower Eocene (*Morozovella aragonensis-Araninina pentacamerata* Zone) of Kazakhstan, but these specimens might in fact represent another species.

Family Carpiliidae Ortmann, 1893
Genus *Eocarpilius* Blow & Manning, 1996

Type species: *Eocarpilius carolinensis*, by original designation.

Eocarpilius sp.

Material: two specimens in the C. Riemslag Collection (Zuidzande, the Netherlands), previously illustrated by Fraaye (1998) and Fraaije (2003) as *Harpactocarcinus* sp., plus a single carapace (MAB k.2449) illustrated here (Fig. 7).

Locality: beach near Nieuwvliet-Bad.

Discussion. Material previously referred to as *Harpactocarcinus* sp. by Fraaye (1998) and Fraaije (2003) is reassigned to the genus *Eocarpilius*, which so far comprised two species from the middle Eocene of north Carolina (Blow & Manning, 1996; Feldmann *et al.*, 1998) and one from the middle Miocene of Hungary (Müller, 1984; Feldmann *et al.*, 1998; Schweitzer *et al.*, 2000; Schweitzer, 2003). The present record extends the Eocene range (as documented in eastern north America) of the genus to northwest Europe, and suggests that dispersal during the Eocene across the Atlantic must have been particularly rapid (see Schweitzer, 2000, 2003).

Family Geryonidae Colosi, 1924
Genus and subgenus *Coeloma* (*Coeloma*) A. Milne Edwards, 1865

Type species: *Coeloma vigil* A. Milne Edwards, 1865, by original designation.

Coeloma (*Coeloma*) *balticum* Schlüter, 1879

Material: a single specimen in the collections of the Natuurhistorisch Museum Rotterdam, NMR 9937-01144.

Localities: having been collected from the so-called "basaalconglomeraat" (see Posthumus, 1923; De Neve, 1945) at Ootmarsum, the present specimen (Figs. 5-6) is considered to have been reworked from Eocene strata.

Figs. 1-8 – 1-4) *Goniocypoda verheyeni* n. sp., holotype (MAB k.2440), middle-late Eocene, Nieuwvliet-Bad (Zeeland, The Netherlands), in orbital, dorsal, ventral and posterior views, respectively. 5-6) *Coeloma* (*Coeloma*) *balticum* Schlüter, 1879, either remanié Eocene or genuine Oligocene element, from the so-called 'basaalconglomeraat' at Ootmarsum (Overijssel, The Netherlands). Specimen NMR 9937-01144 in the collections of Natuurhistorisch Museum Rotterdam, in oblique orbital and dorsal views, respectively. 7) *Eocarpilius* sp. (MAB k.2449), middle-late Eocene, Nieuwvliet-Bad (Zeeland, The Netherlands), in dorsal view. 8) *Glyphithyreus wetherelli* (Bell, 1858) (MAB k.2450), middle-late Eocene, Nieuwvliet-Bad (Zeeland, The Netherlands), in ventral view.

However, it cannot be ruled out entirely that it does represent a genuine early Oligocene record of the species; precise collection data for this specimen are wanting. Previous records include the middle-upper Eocene of Cadzand and Nieuwvliet-Bad (Fraaye, 1998; Fraaije, 2003) and the middle/upper Eocene-lower Oligocene of northern Germany (Gramann & Mutterlose, 1975; Lienau, 1984; Freess, 1992; Polkowsky, 2005).

Discussion. Schlüter (1879, pp. 604-608, pl. 18, fig. 3) recorded *Coeloma balticum* from the 'Unter-Oligocän an der Ostseeküste', on the basis of specimens 'aus der "blauen Erde" der Bernsteingrube Palmicken [*sic*]'. As Jagt *et al.* (2006, p. 368) have recently noted, the age of the 'Bernsteinformation' at Yantarnyi, Samland Peninsula (Kaliningrad district, Russia), formerly Palmnicken in east Prussia, is middle Eocene (Lutetian), rather than early Oligocene (see Ritzkowski, 1997). This suggests that the type material of *C. balticum* is of middle Eocene age; the species apparently does range upwards into the (lower) Oligocene as records from the Netherlands and northern Germany show (Polkowsky, 2005).

Discussion

In comparison with faunas recorded from elsewhere in Europe, the co-occurrence in the beach assemblages from Cadzand and Nieuwvliet-Bad of members of the (sub)genera *Coeloma* (*Coeloma*), *Eocarpilius*, *Goniocypoda* and *Glyphithyreus* would appear to be indicative of a middle Eocene age. However, the new species of *Goniocypoda* indicates a tendency for the carapace in this genus to become wider with time, and this, combined with a northerly dispersal during the middle Paleogene as well as with mass occurrences of carpiliids and *Coeloma* recorded from northern Germany (see Förster & Mundlos, 1982), cannot completely rule out a late Eocene date for these assemblages either.

References

Bittner A., 1893 – Decapoden des pannonischen Tertiär. *Sitzungsberichte und Denkschrift der Akademie der Wissenschaften zu Wien*, Wien, 102: 44-55.

Blow W. C. & Manning R. B., 1996 – Preliminary descriptions of 25 new decapod crustaceans from the middle Eocene of the Carolinas, U.S.A. *Tulane Studies in Geology and Paleontology*, New Orleans, 29: 1-26.

Carter J., 1898 – A contribution to the palaeontology of the decapod Crustacea of England. *Quarterly Journal of the Geological Society*, London, 54: 15-44.

Collins J. S. H. & Morris S. F., 1978 – New lower Tertiary crabs from Pakistan. *Palaeontology*, London, 21: 957-981.

Crane M. D., 1981 – Hexapod crabs of the genus *Goniocypoda* H. Woodward from the Upper Eocene of Hampshire. *Zoological Journal of the Linnean Society*, London, 72: 1-19.

Crane M. D. & Quayle J., 1986 – Two new hexapod crabs of the genus *Goniocypoda* Woodward (Crustacea, Decapoda) from the Hampshire Basin. *Tertiary Research*, Leiden, 7: 101-105.

De Neve G. A., 1945 – *Coeloma balticum* Schlüter uit het basaal-conglomeraat van het Oligoceen in Oost-Nederland. *Geologie en Mijnbouw*, Utrecht, 7: 8-10.

Feldmann R. M., Bice K. L., Schweitzer Hopkins C., Salva E. W. & Pickford K., 1998 – Decapod crustaceans from the Eocene Castle Hayne Limestone, North Carolina: paleoceanographic implications. *The Paleontological Society, Memoir*, Tulsa, 48: 1-28.

Förster R. & Mundlos R., 1982 – Krebse aus dem Alttertiär von Helmstedt und Handorf (Niedersachsen). *Palaeontographica*, Stuttgart, A 179: 148-184.

Fraaye R., 1998 – Paleogene krabben op het strand van Cadzand en Nieuwvliet-Bad. In: Gids voor strandfossielen van Cadzand en Nieuwvliet-Bad. Haaien- en roggentanden, schelpen, krabben, slangsterren, zoogdierresten. Lindemann T. (ed.). *Geode*, Amsterdam, 30: 68-72.

Fraaije R. H. B., 2003 – Paleogene krabben op het strand van Cadzand en Nieuwvliet-Bad. In: Gids voor strandfossielen van Cadzand en Nieuwvliet-Bad. Lindemann T. & Fraaije R.H.B. (eds). *Oertijdmuseum De Groene Poort*, Boxtel: 68-72.

Freess W. B., 1992 – Crustaceen aus den mitteloligozänen Meeressanden bei Leipzig. *Aufschluss,* Heidelberg, 43: 361-375.

Glaessner M. F., 1933 – New Tertiary crabs in the collection of the British Museum. *The Annals and Magazine of Natural History*, London, (10) 12: 1-28.

Glaessner M. F. & Rao V. R., 1960 – A new species of crab from the early Tertiary Fuller's Earth deposits of Kapurdi, Rajasthan, western India. *Records of the Geological Survey of India*, Calcutta, 86: 675-682.

Gramann F. & Mutterlose J., 1975 – Krebsfunde aus dem Alttertiär am Sarstedt-Lehrter Salzstock (Dekapoda, Eozän, Oligozän, Niedersachsen) (Das nordwestdeutsche Tertiärbecken, Beitrag Nr. 17). *Berichte der Naturhistorischen Gesellschaft zu Hannover,* Hannover, 119: 379-401.

Guinot D., 2006 – Rediscovery of the holotype of *Paeduma cylindraceum* (Bell, 1859) and description of a new genus of Hexapodidae (Decapoda, Brachyura). *Zoosystema*, Paris, 28: 553-571.

Ilyin I. V., 2005 – Melovye i paleogenovye desiatinogie rakoobraznye (Crustaceomorpha, Decapoda) zapadnoii chasti Severnoi Evrazii. *Izdatel'stvo Moskovskogo Universiteta*, Moskva.

Jagt J. W. M., van Bakel B. W. M., Fraaije R. H. B. & Neumann C., 2006 – *In situ* fossil hermit crabs (Paguroidea) from northwest Europe and Russia. Preliminary data on new records. *Revista Mexicana de Ciencias Geológicas*, 23: 364-369.

Karasawa H. & Schweitzer C. E., 2004 – Revision of the genus *Glyphithyreus* Reuss, 1859 (Crustacea, Decapoda, Brachyura, Xanthoidea) and recognition of a new genus. *Paleontological Research*, Tokyo, 8: 143-154.

Lienau H.-W., 1984 – Die marinen Deckschichten (Mitteleozän-Unteroligozän) der Helmstedter Braunkohlen (Niedersachsen, BRD). *Documenta naturae*, München, 22: 1-120.

Lindemann T. & Fraaije R. H .B., 2003 – Gids voor strandfossielen van Cadzand en Nieuwvliet-Bad. *Oertijdmuseum De Groene Poort*, Boxtel.

Martin J. W. & Davis G. B., 2001 – An updated classification of the recent Crustacea. *Natural History Museum Los Angeles County, Scientific Series,* Los Angeles, 39: 1-124.

Moths H. & Montag A., 2002 – Tertiäre dekapode Krebse aus Geschieben und dem Anstehenden Norddeutschlands und Dänemarks. *Der Geschiebesammler*, Wankendorf, 35: 3-30.

Müller P., 1984 – Decapod Crustacea of the Badenian. *Geologica Hungarica, Series Palaeontologica*, Budapest, 42: 1-317.

Plaziat J.-C. & Secretan S., 1971 – La faune de crustacés décapodes des calcaires à Alvéolines yprésiens des Corbières septentrionales (Aude). *Geobios*, Lyon, 4: 117-142.

Polkowsky S., 2005 – Decapode Krebse aus dem oberoligozänen Sternberger Gestein von Kobrow (Mecklenburg). *Tassados*, Schwerin, 1: 1-126.

Posthumus O., 1923 – Over de fauna der phosphaatlagen in Twente (Beneden-Oligoceen). Bijdragen tot de kennis der palaeontologie van Nederland, II. *Verslag van de Koninklijke Nederlandsche Akademie voor Wetenschappen*, Haarlem, 32: 367-368.

Remy J.-M. & Tessier F., 1954 – Décapodes nouveaux de la partie ouest de Sénégal. *Bulletin de Société géologique de la France*, Paris, (6) 4: 185-191.

Riemslag C., 2003 – Het zoeken van fossielen aan het strand van Cadzand en de Zwarte Polder. In: Gids voor strandfossielen van Cadzand en Nieuwvliet-Bad. Lindemann T. & Fraaije, R. H. B. (eds). *Oertijdmuseum De Groene Poort*, Boxtel: 24-28.

Ritzkowski S., 1997 – K-Ar-Altersbestimmungen der bernsteinführenden Sedimente des Samlandes (Paläogen, Bezirk Kaliningrad). *Metalla*, Bochum, 66: 19-23.

Schlüter C., 1879 – Neue und weniger gekannte Kreide- und Tertiär-Krebse des nördlichen Deutschlands. *Zeitschrift der deutschen geologischen Gesellschaft*, Berlin, 31: 586-615.

Schweitzer C. E., 2000 – Tertiary Xanthoidea (Crustacea: Decapoda: Brachyura) from the west coast of North America. *Journal of Crustacean Biology*, New York, 20: 715-742.

Schweitzer C. E., 2003 – Utility of proxy characters for classification of fossils: an example from the fossil Xanthoidea (Crustacea: Decapoda: Brachyura). *Journal of Paleontology*, Tulsa, 77: 1107-1128.

Schweitzer C. E., 2005 – The genus *Xanthilites* Bell, 1858 and a new xanthoid family (Crustacea: Decapoda: Brachyura: Xanthoidea): new hypotheses on the origin of the Xanthoidea MacLeay, 1838. *Journal of Paleontology*, Tulsa, 79: 277-295.

Schweitzer C. E. & Feldmann R. M., 2001 – Differentiation of the fossil Hexapodidae Miers, 1886 (Decapoda: Brachyura) from similar forms. *Journal of Paleontology*, Tulsa, 75: 330-345.

Schweitzer C. E., Feldmann R. M. & Gingerich P. D., 2004 – New Decapoda (Crustacea) from the middle and late Eocene of Pakistan and a revision of *Lobonotus* A. Milne Edwards, 1864. *Contributions from the Museum of Paleontology, The University of Michigan*, Ann Arbor, 31: 89-118.

Schweitzer C. E., Feldmann R. M., Tucker A. B. & Berglund R. E., 2000 – Eocene decapod crustaceans from Pulali Point, Washington. *Annals of Carnegie Museum*, Pittsburgh, 69: 23-67.

Woodward H., 1867 – On a new genus of shore-crab, *Goniocypoda edwardsi*, from the lower Eocene of Hampshire. *Geological Magazine*, London, 4 (12): 1-3.

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Report of *Ranilia constricta* (A. Milne Edwards, 1880) (Brachyura, Raninidae) from the Tyrrhenian (upper Pleistocene) of Bovetto (Calabria, S Italy)

The studied specimens were collected in Bovetto quarry, located at N of Reggio Calabria (Calabria – S Italy), known for its interesting marine fauna since the second half of the Nineteenth Century. Bovetto series, 45 metres thick, preserves a rich malacological fauna of a warm climate with many specimens of *Strombus bubonius* Lamarck, a typical gastropod from the Tyrrenhian (upper Pleistocene) of Mediterranean area. Rare fossil mammals, as *Dama dama* cfr. *D. tiberina* and *Hippopotamus* cfr. *H. amphibius*, have been discovered in Bovetto series. Very rare decapod crustaceans are sometimes discovered in the quarry.

These decapod specimens, three-dimensionally preserved, show the following morphological characters: carapace suboval, strongly convex from side to side, flattened, almost straight in midline. Front slightly raised. Anterolateral margins of carapace subparallel and posterolateral convergent. Maximum width of carapace between lateral spines. Preorbital, supraorbital, and extraorbital spines strong and prominent. Anterolateral margin with one spine prominent and elongate. Orbits forming inverted V directed obliquely ventral from rostrum. Dorsal surface of rostrum smooth. Chelipeds stout having surface ornamented with tubercles and ciliate lines. Movable finger of chela unarmed. Palm of chela higher than long with ventral margin terminating in a strong spine, and with opposable margin not armed with teeth. Merus of cheliped with blunt dorsal spine.

The above-mentioned morphological characters are typical of *Ranilia constricta* (A. Milne Edwards, 1880) to which the studied specimens are assigned. At present, this species is widespread in the western Atlantic (to Florida Straits and Yucatan Channel, Cuba, off Barbados, and Brazil), Central Atlantic (Ascension Island), and eastern Atlantic (from Senegal to Congo). At present, only one species is recognised in the fossil record, *R. punctulata* Beschin, Busulini, De Angeli & Tessier, 1988, from the lower Eocene (Ypresian) of Valle del Chiampo (Vicenza, N Italy) (Beschin *et al.* 1988), since Feldmann & Maxwell (1990) assigned *R. pororariensis* Glaessner, 1980, from the upper Eocene of New Zealand to *Laeviranina* Lörenthey & Beurlen, 1929. Müller (1993) ascribed some specimens from the Pliocene of Spain to *Ranilia*, but this ascription is still uncertain. Portell & Roger (2003) published a peer-reviewed abstract on the frog crab *Ranilia* from the Pliocene of Florida (United States), and, as reported by Portell & Agnew (2004), a new fossil species will be described.

Notopella Lörenthey & Beurlen, 1929 (*N. vareolata* Lörenthey & Beurlen, 1929, type species) was synonymised to *Ranilia* by Glaessner (1969) and Müller & Collins (1991), while Via Boada (1965, 1969), Jagt *et al.* (1993), and Tucker (1998) considered *Notopella* Lörenthey, 1929, a valid genus within the subfamily Notopodinae.

References

Beschin C., Busulini A., De Angeli A. & Tessier G., 1988 – Raninidae del Terziario berico-lessineo (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 13: 155-215.

Feldmann R. M. & Maxwell P. A., 1990 – Late Eocene Decapod Crustacea from North Westland, South Island, New Zealand. *Journal of Paleontology*, Lawrence, 64 (5): 779-797.

Glaessner M. F., 1969 – Crustacea Decapoda. In: Treatise on Invertebrate Paleontology. Arthropoda 4 (2), *Geological Society of America and University of Kansas*, Lawrence: R399-R533, R626-R628.

Jagt J. W. M., Collins J. S. H. & Fraaije R. H. B., 1993 – A new Early Palaeocene genus of raninid crab (Crustacea, Decapoda) from Denmark, Southern Sweden and The Netherlands. *Contributions to Tertiary and Quaternary Geology*, Leiden, 30 (3-4): 177-182.

Müller P., 1993 – Neogene Decapod Crustaceans from Catalonia. *Scripta Musei Geologici Seminarii Barcinonensis*, Barcelona, 225: 1-39.

Müller P. & Collins J. S. H., 1991 – Late Eocene coral-associated decapods (Crustacea) from Hungary. *Contributions to Tertiary and Quaternary Geology*, Leiden, 28 (1-2): 47-92.

Portell L. & Agnew J. G., 2004 – Florida Fossil Invertebrates. Pliocene and Pleistocene decapod crustaceans. *Florida Paleontological Society*, 4: 1-10.

Portell L. & Roger W., 2003 – Exceptional preservation and concentration of whole-body *Ranilia* (Decapoda: Raninidae) in the Pliocene Intracoastal Formation of Florida. *Geological Society of America, Southeastern Section*, Abstracts with Programs, 35 (1): 68-69.

Tucker A. B., 1998 – Systematics of the Raninidae (Crustacea: Decapoda: Brachyura) with accounts of three new genera and two new species. *Proceedings of the*

Biological Society of Washington, Washington, 111 (2): 320-371.

Via Boada L., 1965 – Ranínidos fósiles de España. Contribución al estudio paleontológico de la familia "Ranidae" (Crustáceos decápodos). *Boletino Instituto Geologíco y Mineralogíco de España*, Madrid, 76: 3-43.

Via Boada L. 1969 – Crustáceos decápodos del Eoceno español. *Pirineos*, Barcelona, 91-94: 1-479.

Fig. 1 – *Ranilia constricta* (A. Milne Edwards, 1880). A) Lateral view. B) Frontal view. C) Dorsal view. D) Reconstruction.

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Alessandro Garassino, Antonio De Angeli & Giovanni Pasini

New decapod assemblage from the Upper Cretaceous (Cenomanian-Turonian) of Gara Sbaa, southeastern Morocco

The previous reports of decapods from the Upper Cretaceous of Morocco are limited to two discoveries of "pinces de crabes" respectively from the Cenomanian of the Akrabou-section of Ziz Formation (C1 unit), and from the upper Cenomanian of the section of Goulmina (C2 unit - upper part), both located in the Errachidia region (Ettachfini & Andreu, 2004). Dutheil (1999) reported the presence of decapod crustaceans in the faunal assemblage of the locality "close to Gara Sbaa", in the upper part of the Kem Kem beds (Cenomanian in age). Garassino *et al.* (2006) described *Cretapenaeus berberus*, a freshwater decapod crustacean, on the specimens gathered by Dutheil from this locality, located more to the north of Gara Sbaa.

The recent discovery of anomurans, brachyurans, and macrurans from a new locality, excavated by field research carried out by one of the authors (G. P.) for the Sezione di Paleontologia degli Invertebrati del Museo di Storia Naturale di Milano, permitted an increasing of the carcinologic knowledge about these systematic groups. The studied specimens were discovered in new deposits at the top of Gara Sbaa escarpment, located in SE Morocco, along the Hamada of Kem Kem, close to the Algerian border. These fossiliferous levels are known in literature as Kem Kem beds (Sereno *et al.*, 1996) from the Upper Cretaceous. The sediments are exposed from NE to SE for an extent of 250 km and they are marked to the N by Tafilalt area, to the E by Hamada of Guir, to the S by Hamada of Kem Kem, and to the W by Precambrian formations and Paleozoics of Anti-Atlas. The studied area, located SW of Taouz, 26 km S/SW of Tafraout, along the Oued Sbaa, is formed by a small sedimentary series, located at the top of a small mesa, known as Gara Sbaa. The new sedimentary levels, covering the upper unit of Kem Kem beds, lie directly on the Cenomanian-Turonian limestones. These levels, having a small extent (about 500 m^2) and 1.80 m thick, show at the bottom sublithographic laminated limestones (60/70 cm thick), including the faunal assemblage, the subject of this study. In addition to decapod crustaceans, many invertebrate and vertebrate taxa were discovered in these levels: xiphosurans (first report in N Africa), isopods, peracarids, rare insects (Orthoptera and Hemiptera), traces of marine worms, rare pelagic crinoids (Comatulidae), rare teeth of chondrichthyes, and many well-preserved specimens of actinopterygians. Finally, well-preserved leafy branches and leaves were also discovered. All fossils have a high level of preservation resembling the taphonomy of other "*lagerstätten*" quarries.

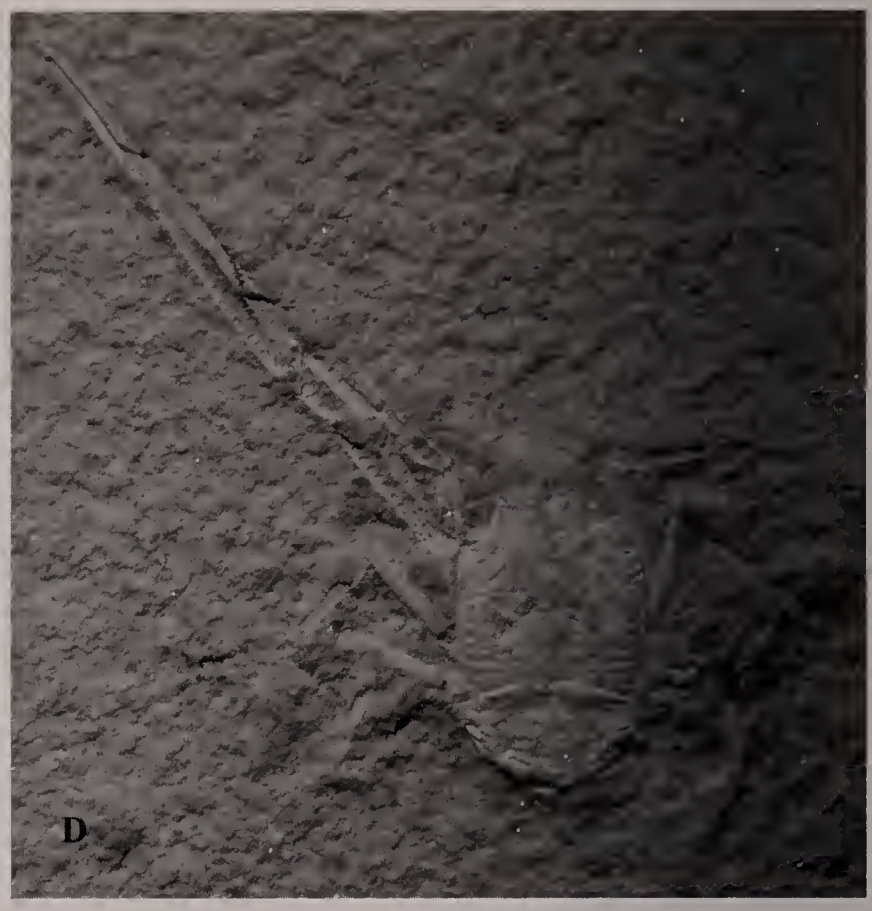
Some specimens of macrurans are assigned to *Cretapenaeus berberus* Garassino, Pasini & Dutheil, 2006, recently described from another locality and unit of the Kem Kem beds.

Many specimens of glypheids are assigned to a new species of *Glyphea* v. Meyer, 1835 (Garassino *et al.*, work in progress). At present, we recognize five species from the Upper Cretaceous: *G. bohemica* Fritsch & Kafka, 1887 (Turonian - Boemia), *G. cretacea* McCoy, 1854, and *G. willetti* (Woodward, 1878) (Cenomanian - Great Britain), *G. damesi* Garassino, 2001 (Cenomanian - Lebanon), and *G. foresti* Feldmann & de Saint Laurent, 2002 (Cenomanian - Australia) which differ from the new species by the presence of two or three carinae in gastric and antennal regions (only one in the new species) and for the smooth dorsal and ventral margins of rostrum (tuberculate margins in the new species).

Some specimens of galatheids are assigned to a new species of *Galathea* Fabricius, 1793, *Paragalathea* Patrulius, 1960, and to a new genus within the family Galatheidae Samouelle, 1819 (Garassino *et al.*, work in progress). Even though the studied specimens belonging to a new species of *Galathea* partially preserve the rostrum, they show morphological characters comparable with this genus, such as the transverse cristae of the carapace and the triangular shape of the rostrum. The new species differ from the other fossil species by the carapace being weakly developed in length, with almost rectilinear cristae continuous to the lateral margins, and exhibiting very developed spines of the rostral margins. The studied specimens belonging to a new species of *Paragalathea* differ from the other fossil species by having the carapace wider than long and the dorsal granules weakly evident and raised. The studied specimens belonging to a new genus have morphological characters that do not resemble those of the other galatheids known to date. In fact, this new genus has the anterior part of the carapace strongly restricted, the fronto-orbital margin wide, about 0.55 of the maximum width of the carapace; the antero-lateral margins concave and strongly divergent to the small spine of the epibranchial angle; the lateral margins of the carapace with small teeth; and transverse cristae of the median and posterior parts of the carapace that do not reach the lateral margins.

Some specimens of brachyurans are ascribed to *Corazzatocarcinus hadjoulae* (Roger, 1946) and *Telamonocarcinus gambalatus* Larghi, 2004, recently described by Larghi (2004) from the Upper Cretaceous (Cenomanian) of Lebanon.

Finally, some specimens of brachyurans are ascribed to a new genus and new species (Garassino *et al.*, work in progress). These specimens have the carapace as long as wide with dorsal regions weakly marked, front with four lobes, small orbits, supraorbital margin strongly concave, and anterolateral margin with four spines. The sternites are really typical, having an oval elongate shape and narrow anterior part.The sutures 1/2 and 3/4 are complete,



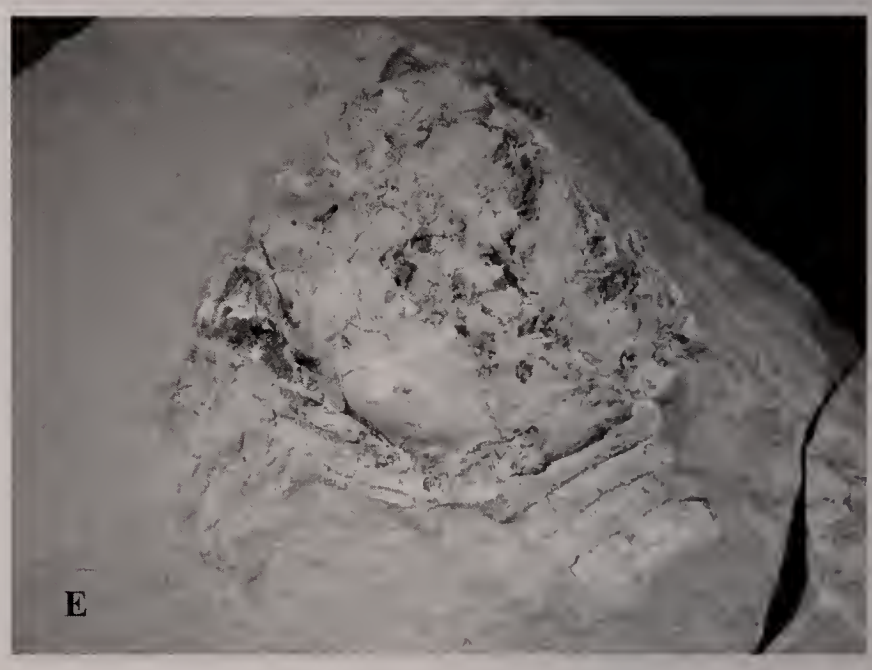


Fig. 1 – A) Glypheidae n. sp., MSNM i26818. B) Galatheidae n. sp., MSNM i26827. C) Galatheidae n. sp., MSNM i26862. D) Galatheidae n. gen., n. sp., MSNM i26856. E-F) Bellidae? n. gen., n. sp., MSNM i26858 (dorsal view), MSNM i26831 (ventral view).

the sutures 4/5, 5/6, and 7/8 are interrupted in the median part, the suture 6/7 is complete, and the sutures 5/6, 6/7 and 7/8 are strongly curved posteriorly; sterno-abdominal cavity weak, deep; vulvae located after suture 5/6. Ambulatory legs II-V elongate with tapering dactyli.

The new genus does not show strict correlations with any crabs known to date. Therefore, we justify the description of a new genus belonging to an indeterminate family within the Eubrachyura.

References

Dutheil D. B., 1999 – An overview of freshwater fish fauna from the Kem Kem beds (Late Cretaceous: Cenomanian) of southeastern Morocco. In: Mesozoic Fishes 2 - Systematics and the fossil Record. Arratia G. & Schultze H.-P. (eds). *Verlag Dr. Friederich Pfeil*: 553-563.

Ettachfini El. M. & Andreu B., 2004 – Le Cénomanien et le Turonien de la Plate-forme Préafricaine du Maroc. *Cretaceous Research*, 25: 277- 302.

Garassino A., Pasini G. & Dutheil D. B., 2006 – *Cretapenaeus berberus* n. gen., n. sp. (Crustacea: Decapoda: Penaeidae) from the Late Cretaceous (Cenomanian) of southeastern Morocco. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (1): 3-17.

Larghi C., 2004 – Brachyuran decapod crustacea from the Upper Cretaceous of Lebanon. *Journal of Paleontology*, Lawrence, 78 (3): 528-541.

Sereno P. C., Dutheil D. B., Iarochène M., Larsson H. C. E., Lyon G. H., Magwene P. M., Sidor C. A., Varricchio D. J. & Wilson J. A., 1996 – Predatory dinosaurs from the Sahara and Late Cretaceous faunal differentiation. *Science*, 272: 986-991.

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Alice Giannetti, Paolo Monaco, Jesús E. Caracuel, Jesús M. Soria & Alfonso Yébenes

Functional morphology and ethology of decapod crustaceans gathered by *Thalassinoides* branched burrows in Mesozoic shallow water environments

Every part of a burrow has an important and specific function with regard to the ecology and trophism of the burrower. It goes from the guarantee of the oxygenation and irrigation of the tunnels to the protection of the organism or the storing of organic material for feeding (Nickell & Atkinson, 1995). Regarding modern thalassinoidean burrows, presence of surface mounds, vertical development of tunnels, geometry of the section of tunnels and horizontal galleries, presence of chambers and of organic debris within the burrows, number and type of apertures on the seafloor, presence of exhalant tunnels and Y- or U-shaped burrow in vertical section, are generally considered as the most important characteristics for ethological characterization of the burrow and of the trace-maker (Nickell & Atkinson, 1995). Some of these features can be recovered also in the trace fossil *Thalassinoides*, usually considered a fossil counterpart of modern thalassinoidean burrows, and they allow one to formulate hypotheses about the trophism of the trace maker. This can be particularly useful in those cases in which body-fossil remains of the burrowers are completely absent and a direct comparison between the morphology of ancient and modern organisms is not possible. Ecologic considerations are here applied to Pliensbachian and Albian *Thalassinoides* developed in the lagoonal deposits of the Trento carbonate platform (Rotzo Member, Calcari Grigi Formation, northern Italy) and in the outer shelf deposits of the Sácaras Formation (Serra Gelada, Alicante Province southeastern Spain), respectively. Different morphotypes of *Thalassinoides* were identified in these two areas, mainly on the basis of dimensions of the branches, diameter of the turning chamber and development and geometry of the maze. Even if *Thalassinoides* like burrows are nowadays produced also by worms and fishes, we consider crustaceans to be the most probable trace makers of the studied *Thalassinoides*. For a detailed discussion of the geological setting, palaeonvironmental models, and ichnology concerning the studied areas see Avanzini (1998), Giannetti (2004), Giannetti & Monaco (2002), Masetti *et al.* (1998), Masetti & Posenato (2002), Monaco (2000a, 2000b), Monaco & Garassino (2001), Monaco & Giannetti (2001, 2002), Winterer & Bosellini (1981), and Zempolich (1993) for the Calcari Grigi Formation, and Caracuel *et al.* (2002), Castro (1998), Giannetti *et al.* (2005), Monaco *et al.* (2005), Vilas *et al.* (1982), and Yébenes (1996) for the Sácaras Formation and references therein.

In the Rotzo Member, three types of *Thalassinoides suevicus* Rieth 1932 (*Thalassinoides* type I to type III, from the smallest to the largest form) and another form type of *Thalassinoides* isp. (type IV) were identified.

Thalassinoides suevicus type I is a small burrow, with a diameter ranging from 2 cm to 5 cm. Branches are thin and circular in section. Turning chambers are not particularly developed. Mazes are regular and geometrical in shape and developed only on the horizontal plane. Burrows are mud-filled and their surface is smooth. When these burrows are in tiered with the other forms of *Thalassinoides*, they occupy the upper tier.

In *Thalassinoides suevicus* type II, the diameter of branches ranges from 5 cm to 10 cm and diameter of turning chambers ranges from 6 cm to 10 cm. Branches are long and form geometrical, sometimes pentagonal mazes. The external surface is smooth and lining is absent. Mudstone or bioclastic wackestone fills the burrows. Bioclasts can be minutely fragmented and grouped in the internal part of the burrow. This is the most frequently observed type of *Thalassinoides* in the studied sections.

Thalassinoides suevicus type III is one of the largest *Thalassinoides* form. Its diameter ranges between 10 cm and 16 cm, and the diameter of the turning chamber is up to 22 cm. Branches are squat with respect to the morphology of the whole burrow and bifurcate at regular angles. The outer surface is smooth and the filling is made of bioclastic wackestones/packstones. Mottled concentrations of minutely fragmented bioclasts can be present in the central part of the burrow, in correspondence to the lumen. This form always occupies the deepest tiers.

In *Thalassinoides* type IV the diameter of the branches can reach 16 cm. The outer surface is mammillary, with small mounds distributed without particular orientation with respect to the burrow. Branches are short, subcircular in section and mazes are irregularly developed. On the outer surface, crinoids and other bioclasts are frequently grouped. Bioclastic wackestone fills the burrows.

Other cylindrical burrows, indicated as *Thalassinoides*? isp., exhibit simple tubes up to 80 cm in length, are gently arched, 6 to 8 cm in diameter, and show short aborted branches, without turning chambers. These traces are very similar in horizontal plane view to those illustrated by Bromley (1990). These atypical, branched tunnels are very different from I-II-III-IV types described above, and are analogous to some burrows of stomatopods from the Seychelles Islands. For their morphological and taphonomic characteristics these simple cylindrical tubes

are not closely related to burrows of shrimps or other decapods, but resemble to those of carnivorous crustaceans (stomatopods, Malacostraca), indicated as active predators, now populating the shallow waters mainly of tropical and subtropical seas.

In the Sácaras Formation, we identified three types of *Thalassinoides suevicus* Rieth 1932 (*Thalassinoides* type A to type C) and another poorly branched form (*Thalassinoides* type D), resembles the *Thalassinoides* ? isp. described for the Rotzo Member, while the type IV is very rare.

Thalassinoides suevicus type A is a small burrow, with a maximum diameter of 5 cm. Turning chambers are present but not particularly developed. It does not show laterally developed mazes, but only burrows with short branches developed only on the horizontal plane. Burrows are mud-filled and their surface is smooth. Similarly to the Rotzo examples, these burrows can be frequently observed tiered with the other forms of *Thalassinoides* and they are placed in the most superficial layers.

In *Thalassinoides suevicus* type B, branch diameter ranges from 6 cm to 8 cm, turning chambers, can reach a diameter of 9 cm. Regular mazes can be well developed on the horizontal plane. The outer surface is smooth, lining is absent and filling is homogenous and made up of bioclastic wackestone.

Thalassinoides suevicus type C is the largest *Thalassinoides* form, with a mean diameter of around 8 cm, and up to 12 cm in size for the turning chamber. When tiering is present, this form is always located in the deepest layers. Filling is homogeneous and made up of bioclastic wackestone.

Thalassinoides isp. type D is a very large, horizontally developed burrow, following an irregular zigzag path. It is up to 1 m long, with a diameter ranging between 10 cm and 14 cm and a circular to slightly elliptical section. It does not show true branching, but only short protrusions, extending in correspondence of the bending point of the burrow. This trace resembles *Thalassinoides*? isp. of Calcari Grigi. Filling is generally homogeneous and is made up of fine-grained calcarenites or by bioclastic wackestone/packstone, according to the lithology of the host rock.

The following interpretation of the trophism of the trace makers and of the ecological significance of the different *Thalassinoides* forms are based on the model proposed by Nickell & Atkinson (1995; fig. 3, p. 195) for modern *Thalassinoides*-like burrows, considering the main features common for both, modern and fossil burrows. The 12 diagnostic features suggested by Nickell and Atkinson (1995) and their ecological significance are here briefly examined.

1) Surface mounds. They are produced by the trace-maker removing sediment from the burrow and transporting it to the surface. Surface mounds formed after the construction of the burrow are indicative of deposit feeding trophic mode. Cone-shaped, muddy mounds, locally crossed by narrow vertical shafts are represented by a few specimens in the Rotzo Member and are completely absent in the Sácaras Formation, maybe due to the higher intensity of bottom currents.

2) Horizontal mazes (it replaces the "tightly layered lattice" feature of Nickell & Atkinson, 1995). They suggest the intense exploitation of the sediment by a deposit feeder. Although all the studied *Thalassinoides* are horizontally developed, this feature is particularly characteristic of *Thalassinoides* type II, forming geometrical mazes widely developed at the base of the beds. As suggested by Suchanek *et al.* (1986), laterally extended mazes would allow the trace makers to maximize the capture of organic material when the substratum has a low nutritional value. This probably could be related to different rates of nutrient input within the sediment in the various phases of evolution of the lagoon.

3) Deep burrows. Depth of the burrow development within the substratum can indicate the importance of surface sediments as a nutritional source for the trace-maker. The deeper the maze is developed within the sediment, the less the trace maker depends directly on organic materials and current destruction present on the seafloor. Due to the absence of vertical tunnels and to the vertical distribution of the different *Thalassinoides* types within the beds, we have hypothesized that the studied *Thalassinoides*, and in particular the smallest forms, were probably developed at a shallow depth within the substratum. This would indicate a quite strong dependence of the trace makers on organic material present on the seafloor (surface deposit feeders or omnivorous scavengers). We must consider the possibility that parts of burrows were eroded by bottom currents and depth of burrowing within the substratum could have been therefore underestimated. This consideration is particularly important in the Serra Gelada section, where burrows are developed in a relative high-energy environment.

4) Sub-circular tunnel cross section. According to Nickell & Atkinson (1995), sub-circular tunnels occur in established burrows, after the phase of exploitation, and are the result of crustacean movement. Oval or irregular shapes are less suitable for efficient water flow than a perfectly circular cross-section (Nickell & Atkinson, 1995). The narrowing in cross section, as occurs in some *Thalassinoides*? isp. (such as in some modern burrows of stomatopods), is another characteristic which is not ideal to water flow. According to this hypothesis, the occupant of the burrow would be strongly dependent on the surface sediments as a nutritional source and less to current flows. With the exception of *Thalassinoides* type IV, all the studied *Thalassinoides* both in the Calcari Grigi and in the Sácaras Formation have a sub-circular cross section or narrowing, thus confirming the hypothesis suggested by the other characters that the primary nutritional source was the organic material present on the seafloor rather than that transported passively by current flow within the tunnels.

5) Chambered burrows. Chambers can have different purposes: they can be used for sub-surface deposit feeding or to store coarse grained material and fragmented bioclasts, found within the substratum or coming from the sea-floor. Another purpose maybe the change the direction of crustacean by 180°, by performing a somersault followed by a roll around the body axis, as observed in modern examples of thalassinoideans. Therefore, the subspherical shape of chambers maybe important to recognize behaviour patterns, in the relationship with charateristics of the substrate (Monaco & Giannetti, 2002). In *Thalassinoides* type III, type IV and secondarily in *Thalassinoides* type II of the Calcari Grigi Formation and type B and C of the Sácaras Formation, turning chambers are particularly

developed and large. Stored coarse grained material such as fragments of crinoids, coated grains and large bivalves, algae and foraminifers were sometimes observed, in particular in *Thalassinoides* type IV.

6) Organic detritus in burrows. Organic detritus in burrows can be the result of scavenging on the surface, but also of passive falling of material within an open burrow. In the fossil record, the different origin of organic detritus can be sometimes identified through taphonomic and sedimentologic criteria. In modern *Thalassinoides*-like burrows, organic material is also used by the crustacean to cultivate micro-organisms for nutritional purposes. Organic detritus in burrows is particularly abundant in *Thalassinoides* type III and type IV.

7) Oblique tunnels were very rarely recorded in the studied sections (in some *Thalassinoides* ? isp.) and therefore they are not considered here.

8) Burrow openings, tubular tempestites. In the studied sections, burrow openings can be directly observed only rarely. Their existence can be deduced by the presence of tubular tempestites inside the bed, but their number, dimensions and density cannot be defined. The presence of many burrow openings would indicate a continuous and necessary contact of the trace maker with the seafloor, for deposit feeding or scavenging.

9) Funnel-shaped openings. According to Nickell & Atkinson (1995), the presence of funnel-shaped openings would facilitate the capture of prey or any other nutritional particles, as they fall down to the sides of the funnel and into the burrow. In the studied section, this feature is represented only by a specimen from the Rotzo Member. The funnel is asymmetric in shape, the back being nearly vertical and the front being flattened probably due to the continuous movement of the trace maker. The bottom of the funnel is connected to a short vertical tunnel, which is not directly related to a preserved *Thalassinoides* maze.

10) Narrow exhalant shaft. The presence of a narrow exhalant shaft indicates the necessity of current generation. This feature was observed only in one cone-shaped mound in the Rotzo Member, but its origin is uncertain.

11) U- or Y- shaped burrows in vertical section. This feature, typical of many modern thalassinoidean burrow systems (Bromley, 1990), was not observed in the studied fossil *Thalassinoides* and therefore it is not considered here.

12) Circular tunnel cross section. Their presence would facilitate the water flow within and through the burrow. Due to the importance of a constant water flow through the burrow, circular tunnel cross sections are present also in burrows produced by primarily deposit feeders and therefore this cannot be considered diagnostic of a particular trophic mode (Nickell & Atkinson, 1995). In the studied sections this feature is only rarely represented in *Thalassinoides* type II and in the largest *Thalassinoides* type III, mainly where mazes are well preserved and regularly developed.

In summary, features representing sediment processing and storage of material for nutritional and maintenance purposes are the most common in the *Thalassinoides* of the Rotzo Member.

The only characteristic shared by the five *Thalassinoides* forms is the horizontal development of the burrows. Branches with a sub-circular section are typical of *Thalassinoides suevicus* type I, type II, and type III. Enlarged chambers are absent in *Thalassinoides suevicus* type I and *Thalassinoides*? isp., present in type II and type III and well developed in type IV.

According to the scheme proposed by Nickell & Atkinson (1995), the most commonly observed features in all the *Thalassinoides* of the Calcari Grigi Formation indicate intense sediment processing. In *Thalassinoides suevicus* type II, type III, and especially in the type IV, storage of organic material (chambered burrows and organic detritus in burrows, characters 5 and 6) is also evidenced. The presence of organic detritus is represented by coarse-grained to fine-grained crushed bioclasts within *Thalassinoides suevicus* type II, type III, and type IV. It indicates both biogenic sorting and storage of bioclastic debris coming from the seafloor and fallen down or trasported into the burrow. The local concentration of coarse-grained fragmented shells in *Thalassinoides* type IV, is probably due to the need of the trace maker to maintain other parts of burrow free from debris.

Vertical tunnels and apertures on the seafloor (characters 8, 9 and 12) are very rarely observed and it is sometimes impossible to state if vertical tunnels are not preserved due to sedimentologic or diagenetic processes or if they were really poorly developed in the burrows. Actually, we have no evidences of deep burrows with a U- or Y- shaped vertical morphology. We have hypothesized, therefore, that mazes were burrowed on horizontal planes only at shallow depth in the substratum. The few evidences of vertical tunnels and of exhalant shafts are difficult to relate to *Thalassinoides* mazes. The presence of tubular tempestites inside the beds proves the existence of direct apertures on the seafloor, even if only the horizontal part of the filled burrows can be usually observed. The only clearly observable vertical element has a circular section (character 12), but it is an isolated feature. This tunnel closely resembles the burrows of modern crustaceans and therefore we have considered it separately. In the category of the vertical elements, we have considered also inhalant and exhalant shafts, represented in the Rotzo Member only by an unclear example. Actually, shafts are so small that they could be produced also by worms. These rare vertical elements indicate the presence of suspension feeders, whose primary nutritional source is the water column, and of surface deposit feeders. According to the scheme proposed by Nickell & Atkinson (1995), all the studied *Thalassinoides* belong to the category of the sub-surface deposit feeders (searching for organic particles within the substratum) and secondarily to that of the omnivorous scavengers (Vaugelas, 1990), which ingest organic debris present on the seafloor and deriving from other animals and algae.

Similar interpretations can be proposed for the *Thalassinoides* studied in the Sácaras Formation, even if only four of the twelve characters described by Nickell & Atkinson (1995), namely those related the horizontal development of the burrow (characters 2-5), are well preserved. The problem concerns the vertical development of the burrows, because we have neither direct nor indirect proofs of the existence of vertical tunnels (except *Ophiomorpha* specimens of calcarenites at the top of parasequences of Serra Gelada, see Monaco *et al.*, 2007) and of the type and number of apertures on the seafloor. Anyway, we can hypothesize the presence at least of some vertical tunnels linking the biggest *Thalassinoides*, placed in the deepest tiers within

the sediment, to the seafloor. Intense bioturbation of the more superficial tiers probably obliterated them.

All the studied *Thalassinoides* are horizontally developed (*horizontal mazes*, character 2) and show a sub-circular cross section (character 4), both characters indicative of intense sediment processing.

Presence of enlarged chambers (as in *Thalassinoides suevicus* type B and in *Th. suevicus* type C, character 5) could indicate storage of organic material for feeding purposes or changes in the direction of locomotion. Concentration of skeletal remains (character 6) is rarely observed, due to the high bioclastic content of the host rock and of the burrow filling. Because of the absence of vertical tunnels, we cannot formulate hypotheses about conditions of irrigation and importance of the water column for nutritional purposes (characters 7-12). It is evident that burrowers were closely dependent on nutrients present within and on the substratum as the main feeding source. Therefore, they can be included in the trophic categories of the sub-surface deposit feeders and secondarily in those of the surface deposit feeders and of the omnivorous scavengers.

This is only a first step in the ecological analysis of the *Thalassinoides* trace fossils and of the trophism of their trace-makers. However, an approach which considers the functional morphology of the parts making up modern *Thalassinoides*-like burrows can be useful for understanding of the ecological meaning of ancient burrows produced by extinct crustaceans and can give further information for a more complete paleoenvironmental reconstruction (Monaco *et al.*, 2007). However, this method has to be refined, elaborating a detailed model which compares different types of *Thalassinoides* in different environmental contexts and considering also the functional morphology of modern branched burrows produced not only by crustacean decapods but also by other organisms.

References

Avanzini M., 1998 – Resti di rettili continentali dal Giurassico inferiore della piattaforma di Trento (Italia settentrionale). *Studi Trentini di Scienze Naturali - Acta Geologica*, Trento, 73: 75-80.

Bromley R. G. C., 1990 – Trace fossils, biology and taphonomy. Special topics in paleontology. *Unwin Hyman Ltd*, London: 1-280.

Caracuel J. E., Monaco P., Yébenes, A. & Giannetti A., 2002 – Trazas afines a *Imbrichnus wattonensis* Hallam de edad Albiense en el Prebético de Alicante (Serra Gelada) *Geogaceta*, Zaragoza, 31: 171-174.

Castro J. M., 1998 – Las Plataformas del Valanginiense superior-Albiense superior en el Prebético de Alicante. Unpublished Ph.D. Thesis, University of Granada.

Giannetti A., 2004 – Analisi tafonomica ed ichnologica delle facies a *Thalassinoides* del Mesozoico Tetideo. Unpublished Ph. D. Thesis. University of Perugia.

Giannetti A., Caracuel J. E., Monaco P., Soria J. M. & Yébenes A., 2005 – Sedimentología, tafofacies e icnocoenosis de las parasecuencias albienses de rampa carbonatada externa en el Prebético de Alicante (Serra Gelada). *Geotemas*, Salamanca, 8: 57-62.

Giannetti A. & Monaco P., 2002 – Burrow-Decreasing Upward Parasequence (BDUP): A case study from the Lower Jurassic Trento Carbonate Platform (Southern Alps). *Rivista Italiana di Stratigrafia e Paleontologia*, Milano, 110 (1): 77-85.

Masetti D., Claps M., Giacometti A., Lodi, P. & Pignatti P., 1998 – I Calcari Grigi della Piattaforma di Trento (Lias inferiore e medio, Prealpi Venete). *Atti Ticinensi di Scienze della Terra,* Pavia, 40: 139-183.

Masetti D. & Posenato R., 2002 – The Trento Plateau and the Belluno Basin. Field trip B5. Stop.3-Valbona. The Middle Liassic *Lithiotis* facies of the Trento Platform (Calcari Grigi, Membro di Rotzo). *General Field Trip Guidebook,* 6th International Symposium on the Jurassic System, Palermo (Italy): 283-288.

Monaco P., 2000a – Biological and physical agents of shell concentrations of *Lithiotis* facies enhanced by microstratigraphy and taphonomy, Early Jurassic, Gray limestones Formation, Trento area (Northern Italy). *GeoResearch Forum*, Zurich, 6: 473-485.

Monaco P., 2000b – Decapod burrows (*Thalassinoides, Ophiomorpha*) and crustacean remains in the Calcari Grigi, lower Jurassic, Trento platform (Italy). In: 1st Workshop on Mesozoic and Tertiary decapod crustaceans. *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore: 55-57.

Monaco P., Caracuel J. E., Giannetti A., Soria J. & Yébenes A., 2007 – *Thalassinoides* and *Ophiomorpha* as cross-facies trace fossils of crustaceans from shallow-to-deep-water environments: Mesozoic and Tertiary examples from Italy and Spain. In: 3rd Symposium on Mesozoic and Cenozoic Decapod Crustaceans. Museo di Storia Naturale di Milano, May 23-25, 2007. A. Garassino, R. M. Feldmann & G. Teruzzi (eds.). *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, XXXV (II): 79-82.

Monaco P. & Garassino A., 2001 – Burrowing and body fossil of decapod crustaceans in the Calcari Grigi, Lower Jurassic, Trento platform (Italy) *Geobios*, Lyon, 34 (3): 291-301.

Monaco P. & Giannetti A., 2001 – Stratigrafia tafonomica nel Giurassico Inferiore dei Calcari Grigi della Piattaforma di Trento. Pavia. *Atti Ticinensi di Scienze della Terra*, Pavia, 42: 175-209.

Monaco P. & Giannetti A., 2002 – Three-dimensional burrow systems and taphofacies in shallowing-upward parasequences, Lower Jurassic carbonate platform (Calcari Grigi, Southern Alps, Italy) *Facies*, Erlangen, 47: 57-82.

Monaco P., Giannetti A., Caracuel J. E. & Yébenes A., 2005 – New shell-armoured burrows (*Ereipichnus geladensis*, n. ichnogenus) and associated echinoid trace fossils from the Prebetic of Alicante (Lower Cretaceous, SE Spain). *Lethaia*, Oslo, 38: 1-13.

Nickell L. A. & Atkinson R. J. A., 1995 – Functional morphology of burrows and trophic modes of three thalassinidean shrimp species, and a new approach to the classification of thalassinidean burrow morphology. *Marine Ecology Progress Series*, Halstenbek, 128: 181-197.

Suchanek T. H., Colin P. L., McMurtry G. M. & Suchanek C. S., 1986 – Bioturbation and redistribution of sediment radionuclides in Enewetak Atoll lagoon by callianassid shrimp; biological aspects. *Bulletin of Marine Science*, Coral Gables (FL) 38 (1): 144-154.

Vaugelas J. V. d., 1990 – Ecologie des callianasses (Crustacea, Decapoda, Thalassinidea) et miléu recifal Indo-Pacifique. Conséquences du remaniement sédimentaire sur la distribution des materies humiques, des métaux traces, et des radionucléides. Memoire présenté à l'Université de Nice - Sophia Antipolis pour l'obtention du Diplome d'Habilitation à diriger des recherches en sciences.

Vilas L., Arias C., Elizaga A., Garcìa de Domingo A. & Lòpez Olmedo F., 1982 – Consideraciones sobre el Cretàcico inferior de la Zona de Jumilla-Yecla. *Cuadernos de Geología Ibérica*, Madrid, 8: 635-650.

Winterer E. L. & Bosellini A., 1981 – Subsidence and sedimentation on Jurassic passive continental margin, Southern Alps, Italy. *AAPG Bulletin*, Tulsa, 65 (3): 394-421.

Yébenes A., 1996 – Estratigrafía y estructura de la Serra Gelada. *Cuadernos de Geografía de la Universidad de Valencia* (60): 201-222.

Zempolich W. G., 1993 – The drowning succession in Jurassic carbonates of the Venetian Alps, Italy: a record of supercontinent breakup, gradual eustatic rise, and eutrophication of shallow-water environments. In Carbonate Sequence Stratigraphy - Recent Developments and Applications. *AAPG Memoir*, Tulsa, 57: 63-105.

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Danièle Guinot, Antonio De Angeli & Alessandro Garassino

Discovery of the oldest eubrachyuran crab from the Middle Jurassic (Bathonian) of Normandy (France)

The studied specimen was discovered in Normandy (Calvados, France) in a quarry at Ranville, located near the city of Caen on the right bank of Orne river. It was collected from the top of the *Hollandi* Subzone (*Discus* Zone) of the Calcaire de Langrune Fm., a limestone formation of the upper Bathonian (Middle Jurassic). The Jurassic deposits at Ranville have long been a source of interesting fossil materials (Rioult *et al.*, 1991). The interesting fauna from this region includes sponges, bryozoans, gastropods, bivalves, ammonite and nautiloid cephalopods, brachiopods, crinoids, and also several crustacean families (Van Straelen, 1925), contrary to the unfortunate sentence in Guinot *et al.* (2005).

The studied specimen is an incomplete three-dimensional, well-preserved carapace, ascribed to the infraorder Brachyura Latreille, 1802, and referred to the family Corystidae Samouelle, 1819, in which it constitutes a new genus and a new species (Guinot *et al.*, work in progress). The morphological characters of the carapace exhibit affinities with the representatives of the family Corystidae, especially *Corystes* Bosc, 1802, with *C. cassivelaunus* (Pennant, 1777) as type species. The similarities are: carapace longer than broad and longitudinally ovate, disposition of grooves on dorsal surface, front narrow and with two teeth (or lobes), relatively wide orbits, raised supra-orbital margin notched by two fissures, antero- and postero-lateral margins not demarcated from each other, postero-lateral margin bearing a subterminal tooth, and posterior margin convex. The only differences are subtle and concern the proportions of the body, slightly wider anteriorly in the studied specimen, the distance between the two extraorbital teeth (fronto-orbital margin), more important in the studied specimen, the tubercles of dorsal surface, slightly stronger in the studied specimen, the grooves, slightly more marked and smooth in the studied specimen (instead of faint and granulated in *C. cassivelaunus*), and the presence of small, smooth areas on frontal and suborbital regions in the studied specimen (instead of a dense and more uniform granulation of these regions in *C. cassivelaunus*). Nevertheless, the French fossil corystid and *C. cassivelaunus* share the same ornamentation of carapace, consisting of isolated tubercles in the anterior half and of clumps of 2-3 small granules in the posterior half.

Our knowledge of the Mesozoic brachyurans is still limited because they are very rare in the fossil record and often are poorly preserved. The fossil Brachyura known from the Jurassic are represented by few primitive forms, all belonging to the Podotremata Guinot, 1977, namely the families Prosopidae v. Meyer, 1860, Homolodromiidae Alcock, 1900, Diaulacidae Wright & Collins, 1972, Dynomenidae Ortmann, 1892, and Homolidae De Haan, 1839 (Glaessner, 1969; Guinot & Tavares, 2001; Schweitzer *et al.*, 2003; Schweitzer & Feldmann, 2005).

The family Prosopidae, recently revised by Wehner (1988) and Müller *et al.* (2000), is an extinct family, with many Mesozoic species, almost exclusively known from carapace materials. Prosopidae, which is supposed to have appeared in the Lower Jurassic (Krobicki *et al.*, 2005), represents a case noted by Schweitzer & Feldmann (2005) of Mesozoic genera disappearing during the K/T event, in contrast to others that became widespread during the Cenozoic. The fossil record suggests that the family Prosopidae is the most ancient podotreme family. Only one other family, the Eocarcinidae Withers, 1932, if it is truly brachyuran, is more ancient.

Förster (1979, 1985) regarded *Eocarcinus praecursor* Withers, 1932, from the Lower Jurassic (lower Pliensbachian) of Great Britain, as the putative ancestor of the Brachyura. He pointed out some morphological characters similar to those of the macruran *Pseudopemphix* Wüst, 1903, from the Middle Triassic (Wellenkalk) of Germany. *Eoprosopon klugi* Förster, 1986, from the Lower Jurassic (upper Pliensbachian) of Germany, was considered an "intermediate form, connecting the Prosopidae with the oldest known crab-like *Eocarcinus*" and was included in the Prosopidae (Förster, 1986). Later, Guinot & Tavares (2001) discussed the relationships of *Eocarcinus*, stressing its morphological features. If *Eocarcinus* Withers, 1932, is confirmed to be a brachyuran crab with a paired spermatheca, it may deserve its own superfamily, and the Eocarcinidae would represent the oldest podotreme family.

The morphological characters of the carapace of the French fossil corystid do not show evident correlations with *Pseudopemphix* (Glypheoidea), nor with *Eocarcinus* and *Eoprosopon* which have more backwardly enlarged carapaces, a concave posterior margin, one developed rostral spine, and complete postcervical and branchial grooves. In the same way, the carapace of the fossil corystid does not resemble that of the Jurassic crabs of the Prosopidae. Furthermore, the fossil corystid does not belong to other podotreme groups as Dromiacea, Homoloidea, or Raninoidea.

Some representatives of the Raninoidea, which appeared at the beginning of the Cretaceous with three genera (*Notopocorystes* McCoy, 1849, *Eucorystes* Bell, 1863, and *Cretacoranina* Mertin, 1941), share some morphological characters of the carapace with the Jurassic corystid, especially the carapace that is elongate, more enlarged forward, relatively convex longitudinally, and the fronto-orbital margin filling the entire anterior margin. We have excluded the Jurassic corystid from the Raninidae for the unbilobate rostrum (*Notopocorystes* excepted),

for the preorbital tooth not distinguished from the rostral spine, not raised and not delimited by a posterior groove. Even though, *Notopocorystes* exhibits a bilobate rostrum, as does the Jurassic corystid, its rostral margins are continuous with the preorbital tooth that is not well raised and not marked posteriorly. Moreover, the trend of the grooves in the anterior part of carapace in *Notopocorystes* (see Withers, 1928; Wright & Collins, 1972; Collins, 1997; Tucker, 1998; Schweitzer & Feldmann 2001) is different from that of the studied specimen, and *Notopocorystes* generally shows a strong longitudinal median carina or median row of tubercles, absent in the studied specimen.

According to Wright & Collins (1972) *Diaulax* Bell, 1863, type genus of the Diaulacidae, appeared in the Upper Jurassic and belongs to "a stock that diverged from Dynomenidae already in the Late Jurassic". The Jurassic fossil does not show any feature of a diaulacid crab.

As a result, the Jurassic fossil is suggested to belong to the Eubrachyura and it is assigned to the Corystidae. Since the studied specimen preserves only the dorsal part of carapace (ventral parts and pereiopods are lacking), and in spite of an evident corystid facies, such an ascription remains uncertain because the Corystidae was known only with three species from the Miocene, *Corystes holsaticus* (Noetling, 1881), *C. latifrons* (Lörenthey *in* Lörenthey & Beurlen, 1929), and *Gomezinus tuberculatus* Collins, Lee & Noad, 2003.

If our hypothesis that the Jurassic specimen belongs to the Corystidae is correct, it represents the oldest record for the Eubrachyura. Moreover, it allows development of new hypotheses about the probable evolutionary relationships of brachyuran crabs. The hypothesis that the cladogenesis Podotremata/Eubrachyura occurred prior to the Jurassic would be confirmed (Guinot & Tavares, 2001, Tab. 16). The studied specimen is most likely the first known Heterotremata.

The identities of the earliest brachyurans are doubtful. The putative Mississippian crab, *Imocaris tuberculata* Schram & Mapes, 1984, is probably not a Brachyura Dromiacea but revealed to be, after the discovery of *I. colombiensis* Racheboeuf & Villaroel, 2003 (Upper Carboniferous – Colombia), an Eocarida Brooks, 1962, and a Pygocephalomorpha Beurlen, 1930 (Racheboeuf & Villaroel, 2003). But for the time being such an assignment is considered uncertain by Schram & Dixon (2004). The Triassic species *incertae sedis* from New Mexico, *Rioarribia schrami* Rinehart, Lucas & Heckert, 2003 (Rinehart *et al.*, 2003; Rinehart & Lucas, in press), supposed to be an eubrachyuran crab, was stated by Schweitzer & Feldmann (2005) not to be a decapod.

So, if our interpretation that the carapace of the French corystid from the Middle Jurassic of Normandy belongs to the Corystidae is correct, an older origination of most basal Hetrotremata than supposed would be demonstrated. Nevertheless, more evidence is required, especially ventral parts, to assert the existence of the Eubrachyura in the Jurassic. The origination of the studied specimen and of the Heterotremata as a whole needs to be found in the more ancient fossil record.

The hypothesis that the Hetrotremata probably evolved in the Jurassic Period is supported by the presence of several authentic heterotreme superfamilies/families in the fossil records known from the Lower or the Upper Cretaceous, including the Dorippoidea MacLeay, 1838 (Vega & Feldmann, 1992; Schweitzer & Feldmann, 2001), the Necrocarcinidae Förster, 1968, the Carcineretidae Beurlen, 1930, and the Hepatidae Stimpson, 1871 (Schweitzer & Feldmann, 2000).

References

Collins J. S. H., 1997 – A systematic survey of the genus *Notopocorystes* McCoy, 1849 (Crustacea, Decapoda, Raninidae). *Bulletin of the Mizunami Fossil Museum*, Mizunami, 23, 1996 (1997): 75-87.

Förster R., 1979 – *Eocarcinus praecursor* Withers (Decapoda, Brachyura) from the Lower Pliensbachian of Yorkshire and the early crabs. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, Stuttgart, 1979 (1): 15-27.

Förster R., 1985 – Evolutionary trends and ecology of Mesozoic decapod crustaceans. *Transactions of the Royal Society of Edinburgh*, Edinburgh, 76: 299-304.

Glaessner M. F., 1969 – Crustacea Decapoda. In: Treatise on Invertebrate Paleontology. Arthropoda 4 (2), *Geological Society of America and University of Kansas*, Lawrence: R399-R533, R626-R628.

Guinot D. & Tavares M., 2001 – Une nouvelle famille de Crabes du Crétacé, et la notion de Podotremata Guinot, 1977 (Crustacea, Decapoda, Brachyura). *Zoosystema*, Paris, 23 (3): 507-546.

Guinot D., Wilson G. D. F. & Schram F. R., 2005 – Jurassic isopod (Malacostraca: Peracarida) from Ranville, Normandy, France. *Journal of Paleontology*, Lawrence, 79 (5): 954-960.

Krobicki M., Müller P. & Zaton M., 2005 – Middle and Upper Jurassic brachyuran crabs – phylogenetic and palaeoenvironmental significance of their early evolutionary stage. Salt Lake City Annual Meeting (October 16–19, 2005), *Geological Society of America, Abstracts with Programs*, 37 (7): 187.

Müller P., Krobicki M. & Wehner G., 2000 – Jurassic and Cretaceous primitive crabs of the family Prosopidae (Decapoda: Brachyura) - their taxonomy, ecology and biogeography. *Annales Societatis Geologorum Poloniae*, Warzawa, 70: 49-79.

Racheboeuf P. R. & Villaroel C., 2003 – *Imocaris colombiensis* n. sp. (Crustacea: Decapoda) from the Pennsylvanian of Columbia. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, Stuttgart, (10): 577-590.

Rinehart L. F., Lucas S. G. & Heckert A. B., 2003 – An early eubrachyuran (Malacostraca: Decapoda) from the Upper Triassic Snyder Quarry, Petrified Forest, north-central Mexico. In: Zeigler K.E., Heckert A.B. & Lucas S.G. (eds), Paleontology of the Snyder Quarry Albuquerque, *New Mexico Museum of Natural History & Science,* Albuquerque, 24: 67-70.

Rinehart L. F. & Lucas S. G., in press – Reillustration of *Rioarribia schrami*, an early eubrachyuran from the

Upper Triassic petrified forest Formation of north-central New Mexico. *Bulletin of New Mexico Natural History Museum*, New Mexico, 37.

Rioult M., Dugué O., Jan du Chêne R., Ponsot C., Fily G., Moron J.-M. & Vail P. R., 1991 – Outcrop sequence stratigraphy of the Anglo-Paris basin, Middle to Upper Jurassic (Normandy, Maine, Dorset). *Bulletin Centres de Recherche Exploitation-Production Elf Aquitaine*, 15 (1): 101-194.

Schram F. R. & Dixon C. J., 2004 – Decapod phylogeny: addition of fossil evidence to a robust morphological cladistic data set. *Bulletin of the Mizunami Fossil Museum*, Mizunami, 31: 1-19.

Schweitzer C. E. & Feldmann R. M., 2000 – New species of calappid crabs from western North America and reconsideration of the Calappidae *sensu lato*. *Journal of Paleontology*, Lawrence, 74 (2): 230-246.

Schweitzer C. E. & Feldmann R. M., 2001 – New Cretaceous and Tertiary decapod crustaceans from western North America. *Bulletin of the Mizunami Fossil Museum*, Mizunami, (28): 173-210.

Schweitzer C. E. & Feldmann R. M., 2005 – Decapod crustaceans, the K/T event, and Palaeocene recovery. In: Koenemann S. & Jenner R. A. (eds.). Crustacea and Arthropod Relationships. *Taylor & Francis Group*, Boca Raton, London, New York, Singapore.

Schweitzer C. E., Feldmann R. M., Fam J., Hessin W. A., Hetricks S. W., Nyborg T. G. & Ross R. M. L., 2003 – Cretaceous and Eocene Decapod Crustaceans from Southern Vancouver Island, British Columbia, Canada. *National Research Council Press*, Ottawa.

Tucker A. B., 1998 – Systematics of the Raninidae (Crustacea: Decapoda: Brachyura), with accounts of three new genera and two new species. *Proceedings of the Biological Society of Washington*, Washington, 111 (2): 320-371.

Van Straelen V., 1925 – Contribution à l'étude des Crustacés Décapodes de la période jurassique. *Bulletin de l'Académie royale Belge*, Bruxelles, Classe Sci., sér. 2, 7: 1-462.

Vega F. J. & Feldmann R. M., 1992 – Occurence of *Costacopluma* (Decapoda: Brachyura: Retroplumidae) in the Maastrichtian of southern Mexico and its paleobiogeographic implications. *Annals of Carnegie Museum*, Pittsburgh, 61 (2): 133-152.

Wehner G., 1988 – Über die Prosopiden (Crustacea, Decapoda) des Jura. Unpublished degree thesis, München.

Withers T. H. 1928 – New Cretaceous Crabs from England and Syria. LIX. *Annals and Magazine of Natural History*, New York, ser. 10, 1: 456-460.

Wright C. W. & Collins J. S. H., 1972 – British Cretaceous crabs. *Palaeontographical Society Monograph*, London, 126: 1-114.

Fig. 1 – Corystid, n. gen., n. sp. from the Middle Jurassic (Bathonian) of Normandy (France) (Guinot *et al.*, work in progress).

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Óscar Hernández-Monzón, Francisco J. Vega & Marco A. Coutiño

A review of *Lophoranina cristaspina* from the Middle Eocene of Chiapas, Mexico and evolutionary implications

A new locality found near the Cerro de Mactumatza (Fig. 1), has yielded more specimens with morphological structures not described previously for *Lophoranina cristaspina* Vega, Cosma, Coutiño, Feldmann, Nyborg, Schweitzer & Waugh, 2001, reported from middle Eocene calcarenites of the San Juan Formation, that crops out near Tuxtla Gutiérrez, Chiapas (Fig. 2). Differences in the shape of lateral spines suggest a possible intraspecific variation, that may represent sexual dimorphism. The review of morphology of more juvenile specimens suggests that general shape of the carapace and ornamentation if preserved through development. The size range for this species is extended to include specimens with relatively large carapaces. A comparison of the only Cretaceous species of this genus and the American and European forms suggest that there were at least two lineages in the evolution of the widespread *Lophoranina*.

Specimens are to be deposited in the Museo de Paleontología ¨Eliseo Palacios Aguilera¨, Instituto de Historia Natural y Ecología de Chiapas, Tuxtla Gutiérrez, Chiapas, under provisional custody of F. Vega.

Systematic paleontology

Order Decapoda Latreille, 1802
Infraorder Brachyura Latreille, 1802
Section Podotremata Guinot, 1977
Subsection Archaeobrachyura Guinot, 1977
Superfamily Raninoidea De Haan, 1839
Family Raninidae De Haan, 1839
Genus *Lophoranina* Fabiani, 1910
Lophoranina cristaspina Vega, Cosma, Coutiño, Feldmann, Nyborg, Schweitzer & Waugh, 2001

Additions to description. Carapace subhexagonal, elongate (Fig. 3 – 1-15). Anterior margin slightly concave, along with anterolateral spines represents the widest part of carapace; three anterolateral spines, outermost either bifid or lobulate, middle one about as long as outer one, but half its width, slightly concave; inner spine semitriangular, as long as other two spines but the widest of all. Sternal segments fused into nearly flat plate, elements 1-3 subpentagonal, with spinose anterolateral margins; element 4 with broad, concave lateral margins. Carpus of cheliped suboval, with six transverse terraces that lack spines; manus semirectangular, with row of spines on lower margin that increase in size toward distal part, where a sharp spine forms highest part of cheliped.

Discussion. Higher taxonomic level are based on Guinot & Quenette (2005). Morphologic variation shown in some specimens of *L. cristaspina* is evident in the shape of the external anterolateral spine. Most specimens show a bifid spine, but others of the same size, have a lobulate shape of this spine. This morphotype is more scarce, and may reflect certain difference related with sexual dimorphism, although this will only be confirmed when specimens with articulated abdomina are found, as pointed out by Feldmann & Schweitzer (in press).

Comparison with carapace shape and anterolateral spines of *L. precocious* Feldmann, Vega, Tucker, García-Barrera & Avendaño, 1996, from the Maastrichtian Angostura and Ocozocoautla formations near Tuxtla Gutiérrez, Chiapas, suggest an evolutionary trend in which the two external spines of the Cretaceous species were fused into a bifid spine in the Eocene species from the same region. The carapace with open lateral spines and wider portion of carapaces at the anterior margin is also observed in *L. bishopi* Squires & Demetrion, 1992. However, the remaining European species (Via, 1959, 1965, 1969; Beschin *et al.*, 2004), as well as *L. georgiana* (Rathbun, 1935) from the Oligocene of SE USA, have a narrow anterior margin, with the widest part of the carapace in the anterior third of carapace length, behind the anterior margin. Based on these features, the following evolutionary trends may be suggested: one includes the Eocene American species, with broad anterolateral spines; another lineage involves all the Tertiary European species, with relatively short anterior margins (Fig. 4). Presence of *L. georgiana* in the Oligocene of Georgia and Alabama may represent the influence of the European linage, once the American lineage became extinct by late Eocene times.

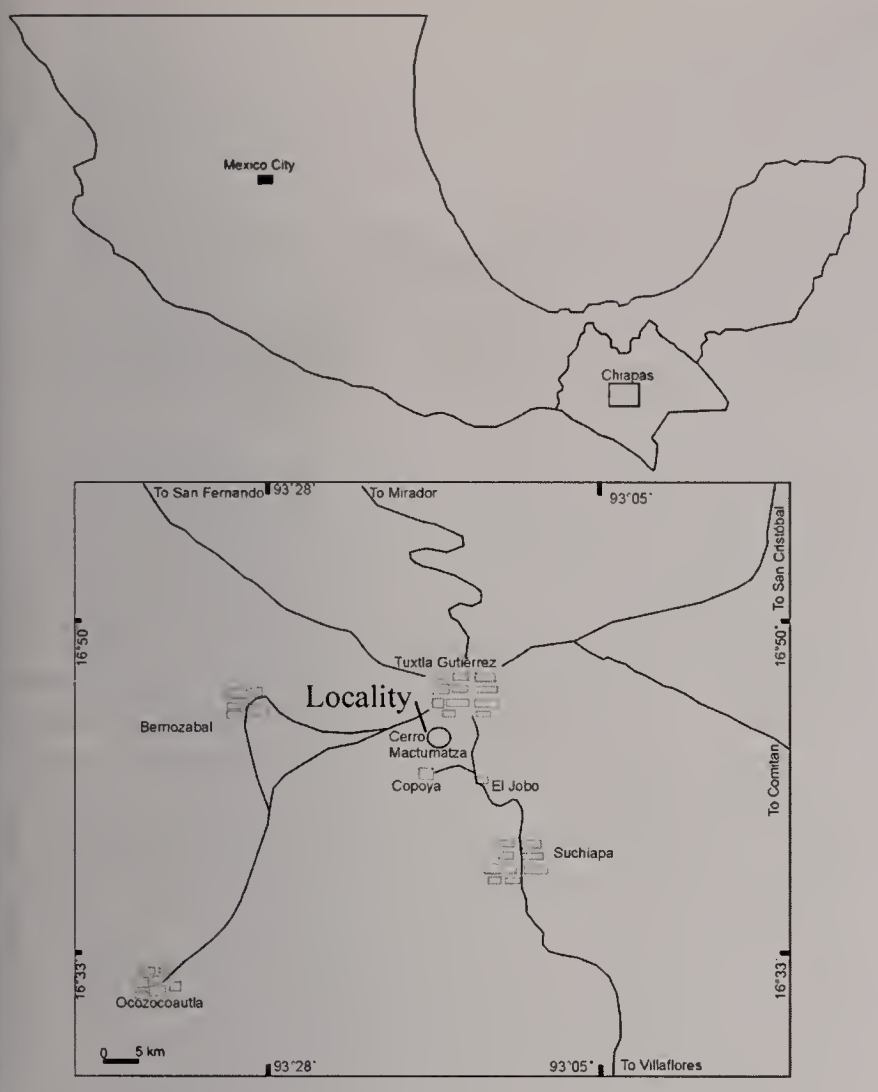

Fig. 1 – Location map of new outcrop near Cerro Mactumatza, south of Tuxtla Gutiérrez, Chiapas.

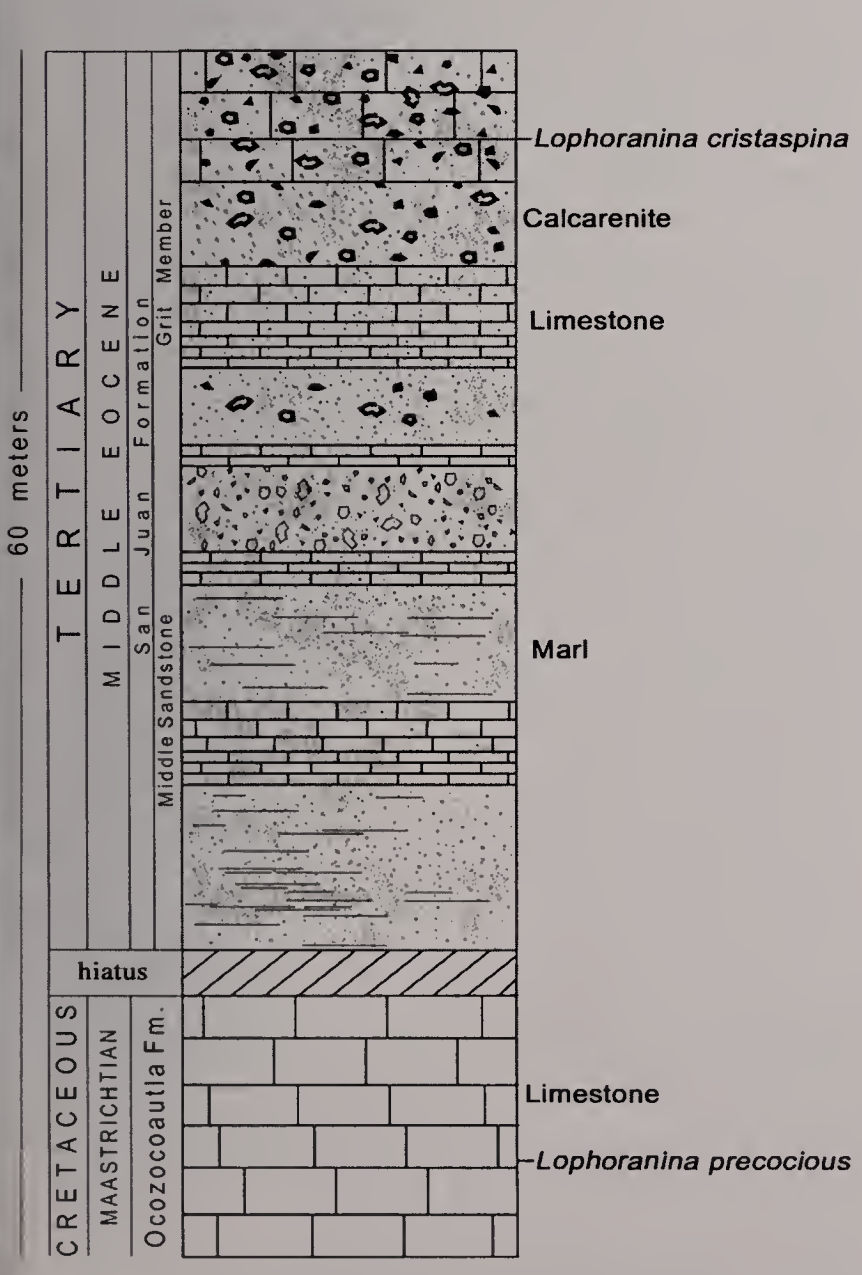

Fig. 2 – Composite Cretaceous-Tertiary stratigraphic section at Cerro Mactumatza, including middle Eocene San Juan Formation.

Figs. 3 – 1-15) *Lophoranina cristaspina* from Cerro Mactumatza, Tuxtla Gutiérrez, Chiapas. 1-2) Mirror images of specimens with bifid spinose and lobulate lateral spines, x 2.0. 3-4) Specimens with bifid spinose lateral spines, x 1.6. 5) Largest specimen, x 1.0. 6) Anterior part of sternum, X1.6. 7-8) Carpi of right and left chelipeds, x 2.8. 9) Outer view of right manus, x 3.0. 10) Inner view of left manus, x 2.0. 11) Outer view of left manus, x 2.0. 12-13) Reconstruction of specimens with bifid and lobulate lateral spines. 14) Reconstruction of sternum.15) Reconstruction of left cheliped.

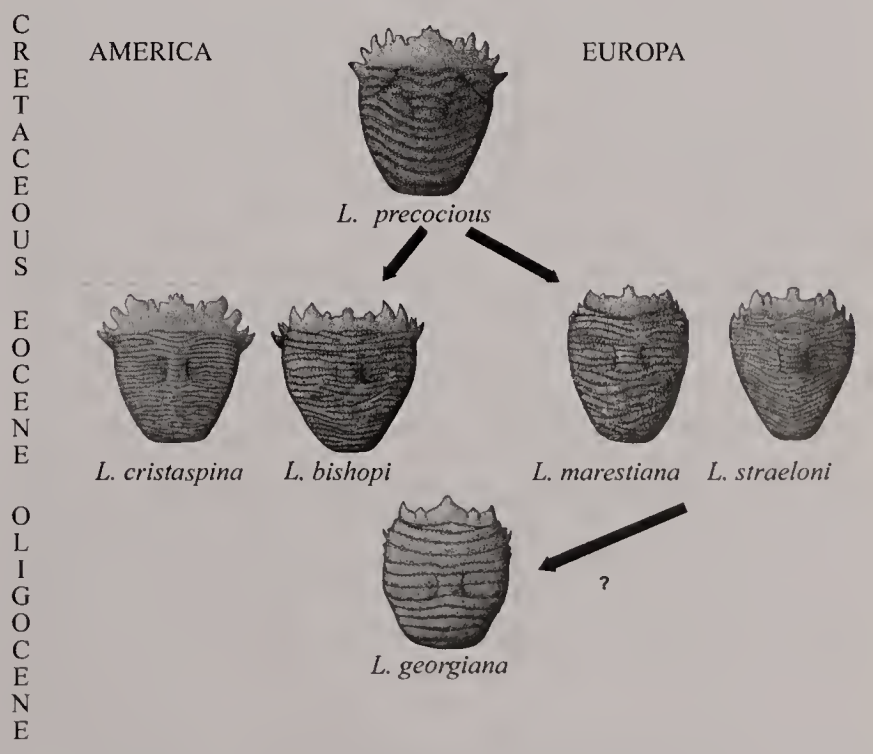

Fig. 4 – Possible evolutionary trends of *Lophoranina*, from the Cretaceous species *L. precocious*.

References

Beschin C., Busulini A., De Angeli A. & Tessier G., 2004 – The Eocene decapod crustacean fauna of the "Main" quarry in Arzignano (Vicenza-NE Italy) with the description of a new species of Raninidae. *Lavori - Società Veneziana di Scienze Naturali,* Venezia, 29: 109-117.

Fabiani R., 1910 – I crostacei terziari del Vicentino. *Bolletino del Museo Civico di Vicenza*, Vicenza, 1: 1-40.

Feldmann R. M. & Schweitzer C., in press – Sexual dimorphism in extinct and extant Raninidae (Decapoda: Brachyura). *Annals of Carnegie Museum*.

Feldmann R. M., Vega F. J., Tucker A. B., García-Barrera P. & Avendaño J., 1996 – The oldest record of *Lophoranina* (Decapoda: Raninidae) from the Late Cretaceous of Chiapas, southeastern Mexico. *Journal of Paleontology,* Lawrence, 70 (2): 296-303.

Guinot D., 1977 – Propositions pour une nouvelle classification des Crustacés Decápodes Brachyoures. *Compte Rendue Académie des Sciences de Paris*, *Serie D*, Paris, 285: 1049-1052.

Guinot D. & Quenette G., 2005 – The spermatheca in podotreme crabs (Crustacea, Decapoda, Brachyura, Podotremata) and its phylogenetic implications. *Zoosystema*, Paris, 27 (2): 267-342.

Haan W. de, 1833-1850 – Crustacea. In: *Fauna Japonica sive descriptio animalium, quae in itinere per Japoniam, jussu et auspiciis superiorum, qui summum in India Batava Imperium tenent, suscepto annis 1823-1830, collegit, notis, observationibus et adumbrationibus illustrativ*. P. F. de Siebold & A. Arnz (eds.). London.

Latreille P. A., 1802-1803 – Histoire naturelle, général et particuliére, des crustacés et des insectes. 3. *F. Dufart*, Paris.

Rathbun M. J., 1935 – Fossil Crustacea of the Atlantic and Gulf Coastal Plain. *Geological Society of America, Special Paper*, Washington, 2.

Squires R. L. & Demetrion R. A., 1992 – Paleontology of the Eocene Bateque Formation, Baja California Sur, Mexico. *Natural History Museum of Los Angeles County Contributions in Science*, Los Angeles, 434: 1-55.

Vega F. J., Cosma T., Coutiño M. A., Feldmann R. M., Nyborg T. G., Schweitzer C. & Waugh D., 2001 – New Middle Eocene Crabs (Crustacea: Decapoda) from Chiapas, Mexico. *Journal of Paleontology*, Lawrence, 75 (5): 929-946.

Vía L., 1959 – Decápodos fósiles del Eoceno español. *Boletín Instituto Geológico y Minero de España,* Madrid, 70: 331-402.

Vía L., 1965 – Ranínidos fósiles de España. Contribución al conocimiento paleontológico de la familia "Raninidae" (Crustáceos, Decápodos). *Boletín del Instituto Geológico y Minero de España*, Madrid, 76: 233-275.

Vía L., 1969 – Crustáceos decápodos del Eoceno español. *Pirineos*, Barcelona, 91-94: 1-479.

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Volume XXXV – Fascicolo II

Matúš Hyžný

Paleogene crab fauna of Borové Formation (localities Ďurkovec and Hlinisko), western Carpathians, Slovakia

The Borové Formation is part of the Podtatranská (Subtatric) Group, which is composed of sedimentary rocks of Paleogene age. The Borové Formation is a typical transgressive formation with occurrences of marine fauna, mostly bivalves and gastropods. The lithology includes breccia, conglomerate, sandstone, limestone, and rarely, also claystone. There are a few regional lithostratigraphic units of the Borové Formation in the Hornádska basin: the Hornád Member, Chrasť Member and Tomášovce Member (Gross *et al.*, 1999). There are some problems with the stratigraphic dating of the Borové Formation because of no, or very few, important fossils for stratigraphic biozonation. The age of each single member of the Borové Formation was determined mostly indirectly. The Borové Formation has a rich macrofauna with remains of decapod crustaceans, especially crabs (Brachyura), which occur at several localities in the Hornádska basin.

The Tomášovce Member represents the uppermost member of the Borové Formation of the Hornádska and Šarišská vrchovina uplands, dating to Priabonian - Lower Oligocene (predominantly the youngest Priabonian) time. The name of this member was taken from the village of Spišské Tomášovce, and the stratotype locality is in the Ďurkovec quarry. The Tomášovce Member represents a complex up to 150 m thick, composed of alternating fine-grained sandstones and siltstones, with pyrite concretions and scarce intercalations of medium-grained carbonate arenites and fine-grained petromict conglomerates. References to the Tomášovce Member as the sandstones with plants imprints and macrofauna" have been known since the 19th century (Hazslinszky, 1852; Miczynski, 1891; Staub, 1891). The Tomášovce Member has been the object of paleontological study by several authors (Gross *et al.*, 1973; Filo & Siráňová, 1996). The layers of the Tomášovce Member contain a hydrophilous tropical flora (predominantly angiosperm plants), a neritic macrofauna (predominantly bivalves) and benthic foraminifers. The faunal assemblages are characteristic of a neritic, marine environment (with the addition of a littoral thanatocoenosis) and a prevalence of euryhaline forms.

Locality Ďurkovec is situated 1 km south from the village of Spišské Tomášovce in the Spišská Nová Ves district. The Ďurkovec quarry was open for the extraction of wall stone - sandstone. Extraction was performed in the past; the Ďurkovec quarry was active about 150 years ago. Modern extraction was opened on two levels. In the sandstones rich in bivalves and Paleogene flora some specimens of decapod crustaceans also have been found, specifically crabs. Crab remains of the Ďurkovec locality were also known in the past, but nobody studied this assemblage. All of the paleontological works and studies of the Paleogene sediments were focused mainly on molluscs (Papšová, 1970, 1973, 1975, 1977, 1978; Volfová, 1960, 1963).

Locality Hlinisko is situated about 2.5 km south from the village Smižany in the Spišská Nová Ves district, about 8 km east-south-east from the Ďurkovec locality. It is about 50 m long. Hlinisko is represented by layers of sandstones and siltstones of the Tomášovce Member. Pyrite concretions are very common. The rocks are strongly eroded and irregularly disintegrated into layers and locally disintegrated shale, unlike the Ďurkovec locality.

Both the Ďurkovec and Hlinisko localities are very rich in fossil remains, mainly subtropical flora and pelecypods, but also including gastropods, echinoids, decapods, and shark teeth. The Spišská Nová Ves district has been the object of paleontological research by the Civic Museum in Spišská Nová Ves since 1988 (Krempaská, 1998). The first study about the crab fauna from this area was published by Hyžný (2006). Crab remains from the mentioned localities are well preserved. Rarely there were found as complete, isolated specimens (*Ranina* (*Ranina*) *speciosa*, *Ranina* sp.), so it is possible to describe the characters of the pereiopods and claws in several cases. Specimens of *Ranina* sp. were collected which probably were preserved in living position, because the orientation of the specimens is almost perpendicular to the bedding planes. At the Ďurkovec quarry locality, there were also collected some trace fossils referred to decapod crustaceans: *Thalassinoides* igen. and *Ophiomorpha* igen. A close relationship between the trace fossils and crab specimens has not been determined until now.

Bittner (1875) mentioned an association of the crab *Coeloma vigil* and the bivalve *Pholadomya puschi* from the marls of northern Italy. Fossils found at the Ďurkovec locality affirm this association. There are also some similarities between the crab fauna of the Tomášovce Member and the transitional layers of the Molare Formation and the Rigoroso Marl in Italy (Allasinaz, 1987).

The environmental interpretation based on the macrofauna and macroflora found at the mentioned localities for the Spišská Nová Ves district is assigned as a shallow marine environment (maximum depth of 200 m).

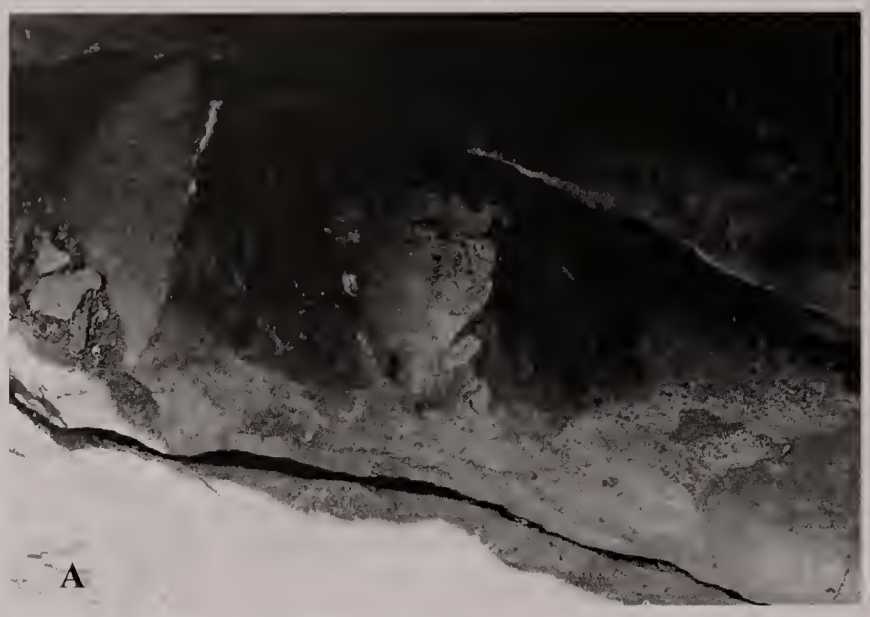
The Decapoda species preliminarily identified from deposits of the Spišská Nová Ves district include:

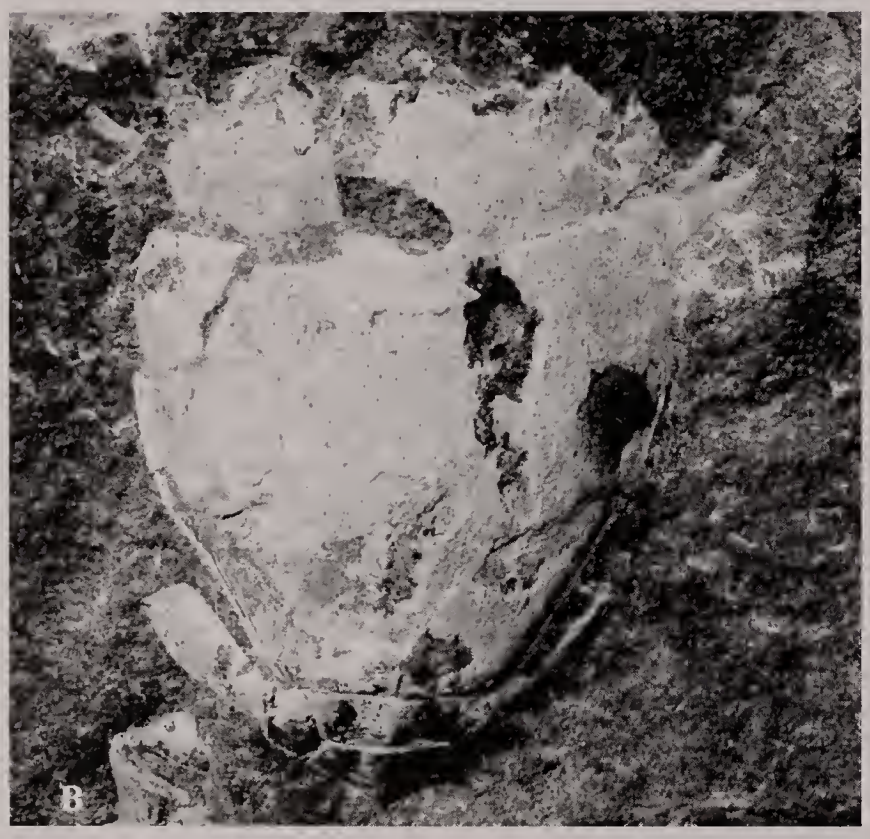
Raninidae: *Ranina (Ranina) speciosa* (Münster, 1840), *Ranina* sp.

Calappidae: *Calappilia* sp.

Portunidae: ?*Portunites* sp.

Geryonidae: *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards, 1865





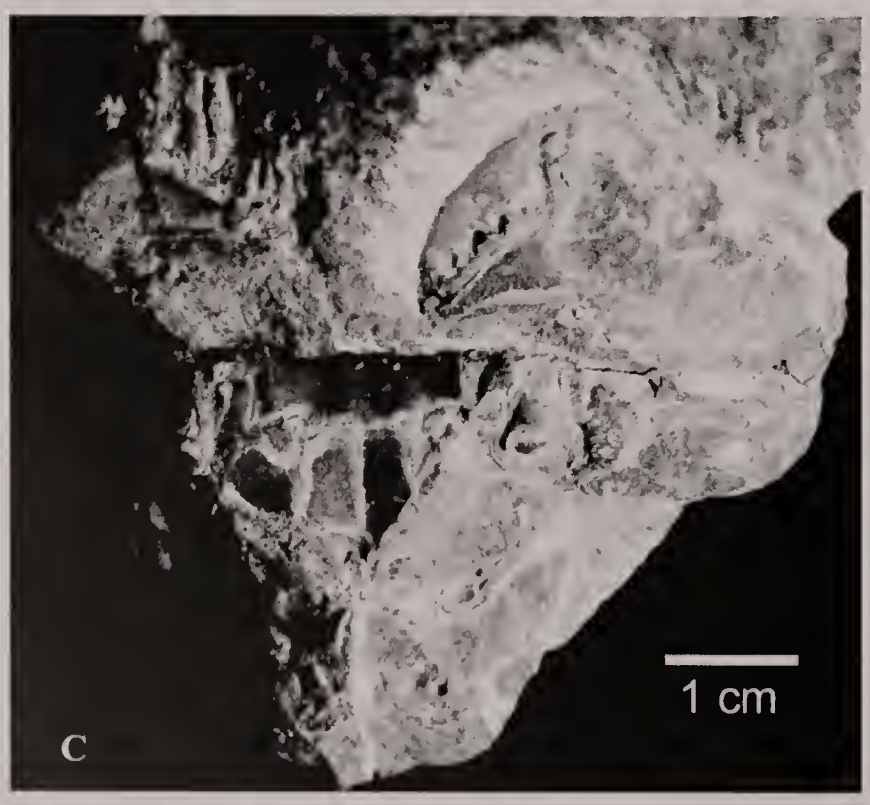


Fig. 1 – A) *Ranina* sp. Specimen orientated almost perpendicular to the bedding planes. Tomášovce Member (Borové formation, Priabonian, lower Oligocene), the Ďurkovec locality, western Carpathians (Slovakia). B) Detail of the same specimen. C) *Ranina* sp. Ventral view on the specimen with preserved claws. Tomášovce Member, the Ďurkovec locality. D) *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards, 1865. Tomášovce Member (Borové formation, Priabonian, lower Oligocene), the Hlinisko locality, western Carpathians (Slovakia). E) *Coeloma* (*Coeloma*) *vigil* A. Milne Edwards, 1865. Tomášovce Member, the Ďurkovec locality. F) *Calappilia* sp. Tomášovce Member, the Ďurkovec locality.

References

Allasinaz A., 1987 – Brachyura Decapoda oligocenici (Rupeliano) del Bacino Ligure Piemontese. *Bollettino Museo Regionale Scienze Naturali Torino*, Torino, 5 (2): 509-566.

Bittner A., 1875 – Die Brachyuren des vicentinischen Tertiärgebirges. *Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe.*

Filo I. & Siráňová Z., 1996 – Tomášovské vrstvy - nova litostratigrafická jednotka podtatranskej skupiny. *Geologické práce, Geologická služba Slovenskej republiky*, Bratislava, Správy 102: 41-49.

Gross P., Buček S., Ďurkovič T., Filo I., Maglay J., Halouzka R., Karoli S., Nagy A., Spišák Z., Žec B., Vozár J., Borza V., Lukáčik E., Janočko J., Jetel J., Kubeš P., Kováčik M., Žáková E., Mello J., Polák M., Siráňová Z., Samuel O., Snopková P., Raková J., Zlinská A., Vozárová A., Žecová K., 1999 – Vysvetlivky ku geologickej mape Popradskej kotliny, Hornádskej kotliny, levočských vrchov, Spišsko-Šarišského medzihoria, Bachurne a Šarišskej vrchoviny. 1:50.000. *Geologická služba Slovenskej republiky, Vydavateľstvo Dionýza Štúra*, Bratislava.

Gross P., Papšová J. & Köhler E., 1973 – Sedimentológia a stratigrafia vrchnej časti bazálnej litofácie centrálnokarpatského paleogénu od Šarišskej vrchoviny po Liptovskú kotlinu. *Manuskript - archív Geologická služba Slovenskej republiky*, Bratislava.

Hazslinszky F., 1852 – Das Thal der Schvinka bei Radács im Sároser Comitate, südöstlich von Eperies. *Jb. K.-Kön. geol. Reichsanst.*, Wien.

Hyžný M., 2006 – Kraby centrálnokarpatského paleogénu. *Bachelor thesis. Prírodovedecká fakulta Univerzity Komenského*, Bratislava, 1-37.

Krempaská Z., 1998 – Niektoré výsledky geologického a paleontologického výskumu v lome Ďurkovec v Slovenskom raji. *Natura Carpatica*, 39: 27-32.

Miczynski K., 1891 – Über einige Pflanzreste von Radacs bei Eperies, Comitat sáros. *Mitt. Jb. Ung. geol. Anst.*, Budapest, 9.

Staub M., 1891 – Etwas über die Pflanzen von Radács bei Eperies. *Mitt. Jb. Ung. geol. Anst.*, Budapest, 9.

Papšová J., 1970 – Záverečná správa o makrofaune paleogénu Liptovskej kotliny na liste Ružomberok /1:50.000/. Čiastková záverečná správa za rok 1970. *Manuskript - archív Geologický ústav Dionýza Štúra*, Bratislava.

Papšová J., 1973 – Sedimentológia a stratigrafia vrchnej časti bazálnej litofácie centrálnokarpatského paleogénu od Šarišskej vrchoviny po Liptovskú kotlinu. Dielčia záverečná správa za rok 1973. *Manuskript - archív Geologický ústav Dionýza Štúra*, Bratislava.

Papšová J., 1975 – Makrofauna strednej časti Liptovskej kotliny na listoch Huty, Demänová, Smrečany, Liptovský Hrádok. Čiastková správa za rok 1975. *Manuskript - archív Geologický ústav Dionýza Štúra*, Bratislava.

Papšová J., 1977 – Celkové zhodnotenie makrospoločenstiev Západných Karpát. Čiastková záverečná správa za rok 1977. *Manuskript - archív Geologický ústav Dionýza Štúra*, Bratislava.

Papšová J., 1978 – Makrofauna paleogénu východnej časti Liptovskej kotliny. Čiastková správa za rok 1978. *Manuskript - archív Geologický ústav Dionýsa Štúra*, Bratislava.

Staub M., 1891 – Etwas über die Pflanzen von Radács bei Eperies. *Mitt. Jb. Ung. geol. Anst.*, Budapest, 9.

Volfová J., 1960 – Stratigraficko-ekologické vyhodnotenie makrofaunistických lokalít centrálneho podtatranského paleogénu /List Vysoké Tatry - Štrba/. *Manuskript - archív Geofond*, Bratislava.

Volfová J., 1963 – Záverečná správa o makrofaune na liste Hranovnica /1:50.000/. *Manuskript - archív Geologický ústav Dionýza Štúra,* Bratislava.

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Hiroaki Karasawa & Hisayoshi Kato

New prosopid crabs (Crustacea, Decapoda, Brachyura) from the Upper Jurassic Torinosu Group, Shikoku, Japan

The extinct podotreme family Prosopidae v. Meyer, 1860, is well known from the Jurassic and Cretaceous deposits of the Tethys realm (Müller *et al.*, 2000). Previously known prosopids from the north Pacific have been *Pithonoton inflatum* Collins & Karasawa, 1993, from the Upper Cretaceous of Japan, *Nipponopon hasegawai* Karasawa, Kato & Terabe, 2006, from the Lower Cretaceous (Barremian) of Japan, and *Nodoprospon* sp. from the Upper Jurassic (Oxfordian) of Japan (Collins & Karasawa, 1993; Karasawa *et al.*, 2006; Kato *et al.*, 2007).

The purpose of the present study is to describe new prosopid crabs from the Upper Jurassic Torinosu Group of Shikoku, Japan. The specimens were collected from shale of the Yatsuji Formation (Kimura, 1956) of the Torinosu Group exposed at Ogawa, Sakawa-cho, Kochi Prefecture (33°29′13″N; 133°14′28″E). Crabs occurred in deposits, in association with mollusks, *Parallelodon* (*Torinosucatella*) *kobayashii* (Tamura), *Entolium yatsujiense* Kurata & Kimura, *Chlamys iboibo* Kurata & Kimura, *Aequipecten* ? spp., *Parvamussium habunokawense* (Kimura), and *Goniomya* (*Goniomya*) *nonvscripta* Tamura (K. Mimoto & T. Hirota, per. com.). Shiraishi *et al.* (2005) showed that the strontium isotopic age of the Yatsuji Formation is 146.1-148.4 Ma (middle Tithonian).

The described and figured specimens are housed in the Mizunami Fossil Museum (MFM) and the Sakawa Geology Museum (SGM), Sakawa-cho, Kochi Prefecture, Japan.

Systematic paleontology

Family Prosopidae v. Meyer, 1860
Subfamily Goniodromitinae Beurlen, 1932
Genus *Goniodromites* Reuss, 1859

Goniodromites hirotai sp. nov.

Diagnosis: large sized *Goniodromites*. Carapace pentagonal, much wider than long, widest at about mid-length. Upper orbital margin rimmed with broadly triangular outer orbital tooth. Anterolateral margin sinuous, sharp, with minute spine just in front of cervical notch and small epibranchial spine. Posterolateral margin sinuous; sharp, tumid margin continuous with anterolateral margin being within anterior third. Dorsal surface irregularly tuberculate, slightly convex transversely and longitudinally. Mesogastric region barely differentiated from protogastric regions, with weak, shallow median depression. Cervical groove well defined. Branchiocardiac grooves poorly defined.

Etymology: the specific name honors Mr. T. Hirota who first discovered the Jurassic decapod fauna from Shikoku.

Material examined: MFM247,020 (holotype) and SGM1297 (paratype) collected by T. Hirota.

Description. Carapace large, pentagonal in outline, wider than long, length about 82% carapace width, widest at about mid-length. Front-orbital margin about 82% maximum width. Frontal margin narrow, about 25% maximum width, with shallow median notch. Upper orbital margin continuous with frontal margin, long, gently convex, rimmed, without fissures. Outer orbital tooth broadly triangular, directed anterolaterally. Anterolateral margin sinuous, sharp, short, bearing minute spine just in front of cervical notch; epibranchial spine present, small, slightly directed backward. Posterolateral margin sinuous, tapering posteriorly; sharp, tumid margin continuous with anterolateral margin reaching at anterior third. Posterior margin slightly concave, rimmed, about 42% maximum width. Dorsal surface irregularly tuberculate on outer mould but nearly smooth on internal mould, slightly convex transversely and longitudinally, with poorly defined regions. Front downturned, sulcate. Epigastric regions elevated. Mesogastric region pyriform, maximum width about 32% carapace width, barely differentiated from protogastric regions, with weak, shallow median depression; anterior mesogastric process separated from epigastric regions by rather deep grooves. Hepatic and protogastric regions not differentiated. Cervical groove well defined, sinuous; lateral elements nearly straight; axial element concave. Urogastric region slightly vaulted longitudinally, separated from branchial regions by shallow, posteriorly converged grooves. Cardiac region triangular, broadest anteriorly, defined by broad, shallow grooves. Branchiocardiac grooves poorly defined, lateral elements nearly parallel lateral elements of cervical groove. Meso- and metabranchial regions not differentiated. Intestinal region weakly depressed.

Discussion. Since Glaessner (1929) has treated *Goniodromites* as the subgenus of *Pithonoton* v. Meyer, 1842, subsequent workers used *Goniodromites* as the subgenus of *Pithonoton* and/or synonymized *Goniodromites* with *Pithonoton*. Most recently, Feldmann *et al.* (2006) recognized *Goniodromites* as a separate genus and included 14 species in it. We agree with their opinion on the generic status of *Goniodromites*. The present species appears to possess internal dorsal carapace characters most like those of *Goniodromites etalloni* (Gemmellaro, 1869) from the Tithonian of Sicily and Romania (Gemmellaro, 1869;

Patrulius, 1966). However, the irregularly tuberculated dorsal carapace readily distinguishes *G. hirotai* from *G. etalloni*. The present species bears an anterolateral spine anterior to the cervical notch and one epibranchial spine, but *G. etalloni* lacks anterolateral spines.

De Angeli & Garassino (2006) synonymized *G. etalloni* with *Goniodromites bidentatum* Reuss, 1859, from the Tithonian of Europe, whereas Feldmann *et al.* (2006) recognized *G. etalloni* as a distinct species. According to Feldmann *et al.* (2006), we treat *G. etalloni* as a separate status because in *G. etalloni* the carapace has a smooth upper orbital margin, no anterolateral tooth, and a posterior mesogastric region with a weak median depression and the maximum carapace width is at about mid-length.

Although hitherto known members of *Goniodromites* have been known from the Middle Jurassic (Bajocian)-Upper Cretaceous (Cenomanian) of the Tethys realm (Feldmann *et al.*, 2006), *G. hirotai* sp. nov. and *G. sakawense* sp. nov. represent the first record from the north Pacific realm.

Goniodromites sakawense sp. nov.

Diagnosis: small sized *Goniodromites*. Carapace pentagonal, slightly wider than long, widest at outer orbital angle. Frontal margin about 40% maximum width, composed of two broadly triangular teeth. Upper orbital margin nearly straight, rimmed, fringed with minute serrations. Lateral margins nearly straight without serrations and spines. Posterior margin concave, rimmed; width about 50% maximum width. Dorsal surface densely rugose, gently convex transversely and longitudinally. Epigastric regions well defined, transversely ridged. Mesogastric region without posterior median depression. Cervical groove well defined. Urogastric region separated from cardiac region by shallow, gently concave groove. Branchiocardiac grooves well developed.

Etymology: the trivial name notes the occurrence of the specimens in Sakawa-cho.

Material examined: MFM247,021 (holotype) and SGM1298 (paratype) collected by T. Hirota.

Description. Carapace small, pentagonal in outline, length about 90% maximum carapace width, widest at outer orbital angle. Front-orbital margin slightly shorter than maximum width. Frontal margin about 40% maximum width, composed of two broadly triangular teeth, medially notched, united with upper orbital margin. Upper orbital margin long, nearly straight, rimmed, fringed with minute serrations; outer orbital angle small, triangular, directed anterolaterally. Lateral margins nearly straight, tapered posteriorly, with cervical and branchiocardiac incisions. Posterior margin concave, rimmed; width about 50% maximum width. Dorsal surface densely rugose, gently convex transversely and longitudinally. Front downturned, sulcate. Epigastric regions well defined, transversely ridged. Mesogastric region pyriform, maximum width about 36% carapace width, barely differentiated from protogastric regions; anterior mesogastric process separated from epigastric regions by deep grooves. Hepatic and protogastric regions not differentiated. Cervical groove well defined, sinuous; lateral elements gently convex or nearly straight; axial element concave. Urogastric region separated from cardiac region by shallow, gently concave groove. Cardiac region triangular, broadest anteriorly. Intestinal region long, defined by shallow grooves joining branchiocardiac grooves. Branchiocardiac grooves well developed; lateral elements nearly parallel lateral elements of cervical groove. Meso- and metabranchial regions not differentiated.

Discussion. The present species is similar to *Goniodromites serratum* Beurlen, 1929, from the Oxfordian-Tithonian of Germany, Belgium, and Poland (Feldmann *et al.*, 2006) and *Goniodromites* sp. Form A from the Oxfordian of Romania (Feldmann *et al.*, 2006). This species differs from *G. serratum* and *G.* sp. Form A in that the lateral margins are smooth without serrations and spines, and the carapace is slightly wider than long. A narrow posterior mesogastric region in *G. sakawense* does not bear a longitudinal groove, while *G. serratum* has a wide posterior mesogastric region with a weak median groove.

Genus *Pithonoton* v. Meyer, 1842

Pithonoton iyonofutanajima sp. nov.

Diagnosis: small to moderate sized *Pithonoton*. Carapace elongate-pentagonal, much longer than wide, widest at about outer orbital angle. Frontal margin rimmed, about 40% maximum width, composed of two rounded lobes, weakly notched medially. Upper orbital margin slightly concave, rimmed. Lateral margins slightly sinuous, with cervical incision. Posterior margin concave, rimmed; width about 45% maximum width. Dorsal surface densely rugose, gently convex transversely and longitudinally. Front strongly protruded anteriorly. Epigastric regions weakly ridged transversely. Cervical groove well defined. Branchiocardiac grooves much shallower cervical groove.

Etymology: the specific name derived from "Iyonofutanajima" meaning Shikoku in the Japanese mythological age.

Material examined: MFM247,022 (holotype) and SGM1299 (paratype) collected by T. Hirota.

Description. Carapace small to moderate, elongate-pentagonal in outline, width about 87% maximum carapace width, widest at about outer orbital angle. Front-orbital margin slightly shorter than maximum width. Frontal margin rimmed, about 40% maximum width, composed of two rounded lobes, weakly notched medially, united with upper orbital margin. Upper orbital margin long, slightly concave, rimmed; outer orbital angle small, triangular, directed anterolaterally. Lateral margins slightly sinuous, tapered posteriorly, with cervical incision. Posterior margin concave, rimmed; width about 45% maximum width. Dorsal surface densely rugose, gently convex transversely and longitudinally. Front downturned, strongly protruded anteriorly, sulcate. Epigastric regions weakly ridged transversely. Mesogastric region pyriform, maximum width about 33% carapace width, barely differentiated from protogastric regions; anterior mesogastric process separated from epigastric regions by rather deep grooves. Hepatic and protogastric regions not differentiated. Cervical groove well defined, sinuous; lateral elements nearly straight; axial element concave. Urogastric region slightly vaulted longitudinally. Cardiac region triangular, broadest anteriorly, defined by broad, shallow grooves. Branchiocardiac

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1c

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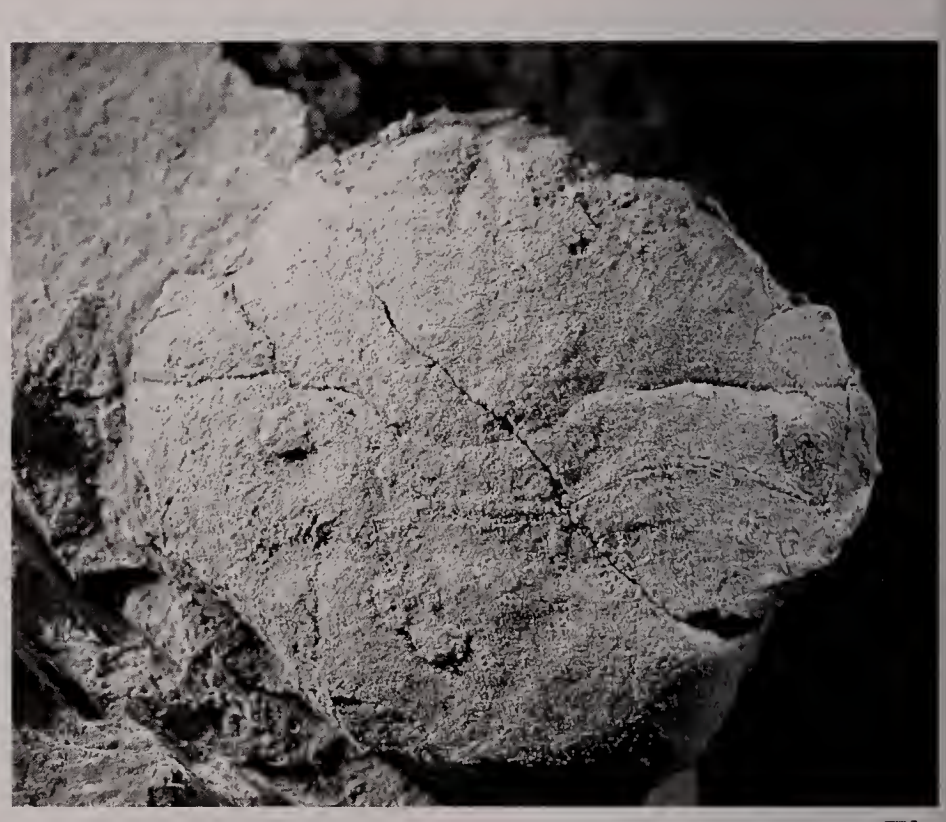
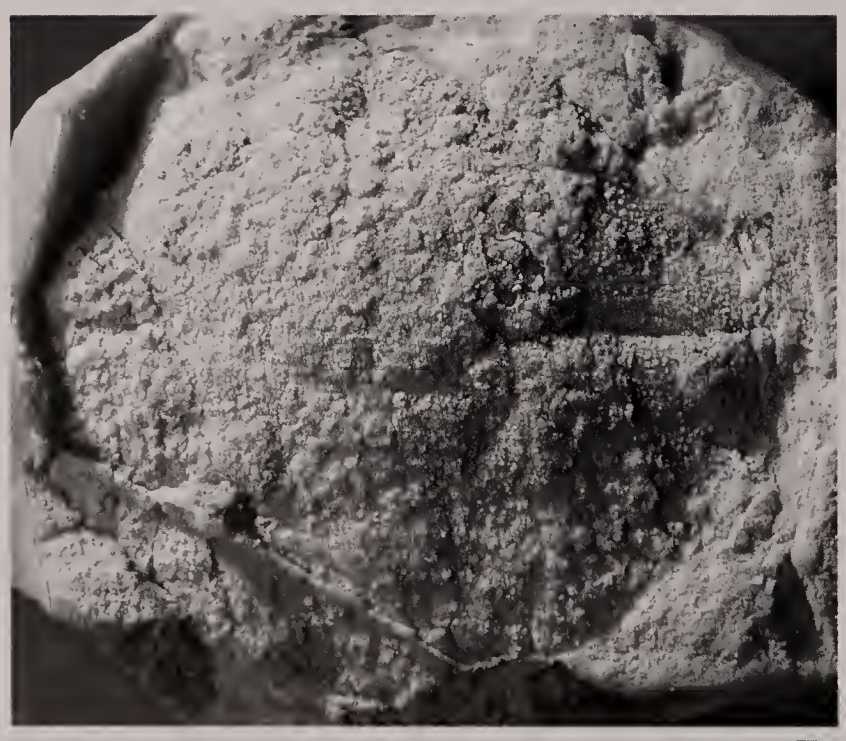


7b



7a

Figs. 1-7 – 1) *Nodoprosopon* sp., SGM1300. a) silicon cast of external mould of carapace; b) internal mould of carapace; c) external mould of carapace. 2) *Pithonoton iyonofutanajima* sp. nov., MFM247,022 (holotype), dorsal view of carapace. 3) *Pithonoton iyonofutanajima* sp. nov., SGM1299 (paratype), dorsal view of carapace. 4) *Goniodromites hirotai* sp. nov., SGM1297 (paratype), dorsal view of carapace. 5) *Goniodromites sakawense* sp. nov., MFM247,021 (holotype), dorsal view of carapace. 6) *Goniodromites sakawense* sp. nov., SGM1298 (paratype), dorsal view of carapace. 7) *Goniodromites hirotai* sp. nov., MFM247,020 (holotype), dorsal view; a) silicon cast of external mould of carapace; b) internal mould of carapace. 1a-c, scale bars = 2 mm; 2, 3, 5, 6, scale bars = 5 mm; 4, 7a-b, scale bars = 10 mm.

grooves shallow, lateral elements nearly parallel lateral elements of cervical groove. Meso- and metabranchial regions not differentiated.

Discussion. The present new species resembles *Pithonoton marginatum* (v. Meyer, 1842) from the Kimmeridgian-Tithonian of Europe (Garassino *et al.*, 2005) and *Pithonoton elongatum* (v. Meyer, 1860) from the Middle-Upper Jurassic of Germany. The elongated front with two rounded lobes, weakly raised epigastric regions, and weak branchiocardiac grooves readily distinguish *P. iyonofutanajima* from *P. marginatum*. This species differs from *P. elongatum* in having a wide front with two rounded lobes, a wide posterior margin, and weak branchiocardiac grooves. The carapace in *P. elongatum* is much longer than wide.

Pithonoton iyonofutanajima represents the second record of *Pithonoton* from the north Pacific rim. Recognition of the present species extends the geologic range for the genus known from the north Pacific rim back to the Tithonian.

Subfamily Prosopinae v. Meyer, 1860
Genus *Nodoprosopon* Beurlen, 1928

Nodoprosopon sp.

Material examined: SGM1300 collected by T. Hirota.

Discussion. The Japanese species closely resembles *Nodoprosopon heydnei* (v. Meyer, 1860) from the Oxfordian-Tithonian of Europe (Kato *et al.*, 2007). Other material is reported from the Oxfordian Somanakamura Group of Fukushima Prefecture, Japan (Kato *et al.*, 2007).

References

Collins J. S. H. & Karasawa H., 1993 – The Cretaceous crab, *Pithonoton inflatum* from Hokkaido, Japan. *Science Reports of the Toyohashi Museum of Natural History*, Toyohashi, 3: 17-20.

De Angeli A. & Garassino A., 2006 – Catalog and bibliography of the fossil Stomatopoda and Decapoda from Italy. *Memorie della Società italiana di Scienze naturale e del Museo civico di Storia naturale di Milano*, Milano, 35 (1): 3-96.

Feldmann R. M., Lazăr I. & Schweitzer C. E., 2006 – New crabs (Decapoda: Brachyura: Prosopidae) from Jurassic (Oxfordian) sponge bioherms of Dobrogea, Romania. *Bulletin of the Mizunami Fossil Museum*, Mizunami, 33: 1-20.

Garassino A., De Angeli A. & Schweigert G., 2005 – Brachyurans from the Upper Jurassic (Kimmeridgian-Tithonian) of Pfalzpaint and Breitenhill (Bavaria, S Germany). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 146 (1): 69-78.

Gemmellaro G. G., 1869 – Crostacei. In: Studi paleontologici sulla fauna del calzare a *Terebratula janitor* del Nord di Sicilia. *Stabilimento Tipografico Lao*, Palermo, Parte I: 11-18.

Glaessner M. F., 1929 – Crustacea Decapoda. In: Fossilium Catalogus: Animalia. J. F. Pompeckj (ed.). *W. Junk*, Berlin, 41: 1-464.

Karasawa H., Kato H. & Terabe K., 2006 – A new member of the family Prosopidae (Crustacea: Decapoda: Brachyura) from the Lower Cretaceous of Japan. *Revista Mexicana de Ciencias Geológicas*, Mexico, 23: 344-349.

Kato H., Takahashi T. & Taira M., 2007 – Decapod crustaceans from the upper Jurassic of Somanakamura Group, northeast Japan: first record of the Jurassic crab from the circum-Pacific region. *Abstracts with Programs, The 156 Regular Meeting of the Palaeontological Society of Japan*, Takushima.

Kimura T., 1956 – The Torinosu Group and the Torinosu Limestone in the Togano and Go Basins, Kochi Prefecture. *The Journal of the Geological Society of Japan*, Tokyo, 62: 515-526.

Müller P., Krobicki M. & Wehner G., 2000 – Jurassic and Cretaceous primitive crabs of the family Prosopidae (Decapoda: Brachyura) - their taxonomy, ecology and biogeography. *Annales Societatis Geologorum Poloniae*, Kraków, 70: 49-79.

Patrulius D., 1966 – Les Décapodes du Tithonique inférieur de Woźniki (Carpates Polonaises Occidentales). *Annales de la Société Géologique de Pologne*, Warzawa, 36 (4): 495-517.

Reuss A. E., 1859 – Zur Kenntnis fossiler Krabben. *Denkschriften der kaiserlichen Akademie der Wissenschaften in Wien*, Wien, 17: 1-90.

Shiraishi S., Hayasaka Y., Takahashi Y., Tanimizu M., Ishikawa T., Matsuoka J., Murayama M. & Kano A., 2005 – Strontium isotopic age of the Torinosu Limestone in Niyodo Village, Kochi Prefecture, SW Japan. *The Journal of the Geological Society of Japan*, Tokyo, 111: 610-623.

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Volume XXXV – Fascicolo II

Michał Krobicki, Pál Müller & Michał Zatoń

Middle and Upper Jurassic European prosopid crabs, phylogeny and palaeoenvironments

The most primitive crabs (Brachyura) of the extinct family Prosopidae are represented mostly by Jurassic and Cretaceous species. The origin of these crabs is more or less enigmatic and mainly based on morphological changes in the surface of their carapaces. Fossil evidence suggests that the family Prosopidae is ancestral to all other brachyurans including Dromiacea and Eubrachyura, with very close phylogenetic relations to Homolodromiidae, Dromiidae, Homolidae, Latreillidae, Dynomenidae, Xanthidae, Cyclodorippoidea and Calappoidea. Prosopids appeared in the late Early Jurassic (Pliensbachian) and therefore most probably accommodate the ancestors of all brachyurans (Müller *et al.*, 2000). Förster (1979), who described the oldest crab species - *Eocarcinus praecursor* Withers, 1932, suggested that this form is in many respects transitional between the macruran Glypheoidea and the early brachyurans. This idea is widely accepted suggesting that this early Pliensbachian *Eocarcinus* is a transitional form between the Triassic glypheoids (*Pseudopemphix*) and earliest, Late Pliensbachian prosopids (*Eoprosopon klugi* Förster). Meyer (1860) was the first to report prosopid crabs and recognised their dromiid affinities. He arranged the 25 known species into a new family Prosopidae. However, the very close relationship of prosopids and the Homolodromiidae is universally accepted (see e.g., Wehner, 1988; Schweitzer *et al.*, 2004), and seems to be well established by the high degree of similarity in carapace traits, patterns of furrows, ventral parts, and, partly, chelae as well.

Most prosopid species were found in the Upper Jurassic limestones, while the Early and Middle Jurassic fossil record of crabs is very poor (e.g., Förster, 1985; Wehner, 1988; Müller *et al.*, 2000; Schweigert, 2006). Prosopids had their climax during this time with a wide distribution in sponge-microbial (Oxfordian) buildups and/or coral reef (Kimmeridgian-Tithonian) environments of Europe (*Pithonoton*, *Coelopus*, *Longodromites*, *Prosopon*, *Foersteria*, *Nodoprosopon*, *Lecythocaris*, *Glaessneropsis*).

Early-Middle Jurassic prosopid crabs, and therefore, presumably also brachyuran evolution, started on shallow-sea, soft bottom environments, where their habitat was probably closely related to oolitic and coral facies, crinoid and also molluscan buildups/shell accumulations, and moderatly deep grey clays sedimentation of Bajocian-Bathonian age (Krobicki *et al.*, 2005). Soon after, the world-wide expansion of epicontinental seas, associated with the Callovian transgression, allowed the formation of bioherms and reefs in the Late Jurassic, creating ideal ecological niches for the rapidly evolving prosopids (Förster, 1985). Numerous crab species following the Oxfordian growth of organogenic, mainly sponge-bearing buildups, documented ecological (probably symbiotic) relationships between the faunal elements (e.g., Müller *et al.*, 2000). These Late Jurassic cyanobacterial-sponge limestones were deposited in deep sublittoral to littoral settings, containing abundant sponges and sporadically hermatypic corals as well (Matyszkiewicz *et al.*, 2006 with references cited therein).

The Mid- to Late Jurassic wide distribution of shallow water environments (maximum a few hundred metres) and in particular the varied reefal habitats around the Tethys Ocean, contributed much to the rapid diversification and success of early crabs (Förster, 1985; Müller *et al.*, 2000). The early episode of crab evolution has been connected with their climax during Late Jurassic time with a wide distribution, probably developed under tropical and subtropical conditions in shallow, warm waters of the sponge and sponge-coral reefs in the Oxfordian-Kimmeridgian, as well as coral reefs in the Tithonian (the so-called Štramberk-type limestones) of the northern Tethyan Ocean. The isolated occurrences of Late Jurassic prosopids outside the centres of "reef" sedimentation suggest that this fauna adapted poorly to non-reefal palaeoecological conditions (Müller *et al.*, 2000). After retreat of reefal facies at the Jurassic-Cretaceous boundary, crab development decreased and, therefore, the Cretaceous fossil record of this fauna is poor and spatially dispersed.

Their closely related descendants, the homolodromiids, preferentially inhabited soft muddy bottoms in deeper, colder waters. Such ecological displacement to deeper habitats is well documented by Tertiary fossils (cf. Feldmann *et al.*, 1991; Collins, 1997). Some homolodromiids actually live even deeper than 1.000 m (Guinot & Forges, 1981).

References

Collins J. S. H., 1997 – Fossil Homolidae (Crustacea; Decapoda). *Bulletin of the Mizunami Fossil Museum*, Mizunami, 24: 51-71.

Feldmann R. M., Tucker A. & Berglund R. E., 1991 – Fossil crustaceans. *National Geographical Research and Exploration*, Washington, 7: 352-363.

Förster R., 1979 – *Eocarcinus praecursor* Withers (Decapoda, Brachyura) from the Lower Pliensbachian of Yorkshire and the early crabs. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, Stuttgart, 1: 15-27.

Förster R., 1985 – Evolutionary trends and ecology of

Mesozoic decapod crustaceans. *Transactions of the Royal Society of Edinburgh, Earth Sciences*, Edinburgh, 76: 299-304.

Guinot D. & de Forges B. R., 1981 – Homolidae, rares ou nouveaux, de l'Indo-Pacifique (Crustacea, Decapoda, Brachyura). *Bulletin du Muséum national d'Histoire naturelle*, Paris, 4 ser., 3, sec. A, 2: 523-581.

Krobicki M., Müller P. & Zatoń M., 2005 – Middle and Upper Jurassic brachyuran crabs - phylogenetic and palaeoenvironmental significance of their early evolutionary stage. *The Geological Society of America, GSA Annual Meeting & Exposition*, Salt Lake City, 16-19 October 2005, Abstracts and Programs: 187.

Matyszkiewicz J., Krajewski M. & Żaba J., 2006 – Structural control on the distribution of Upper Jurassic carbonate buildups in the Kraków - Wieluń Upland (south Poland). *Neues Jahrbuch für Geologie und Paläontologie, Monathshefte*, Stuttgart, 3: 182-192.

Meyer H. von, 1860 – Die Prosoponiden oder die Familie der Maskenkrebse. *Palaeontographica*, Kassel, 7: 183-222.

Müller P., Krobicki M. & Wehner G., 2000 – Jurassic and Cretaceous primitive crabs of the family Prosopidae (Decapoda: Brachyura) - their taxonomy, ecology and biogeography. *Annales Societatis Geologorum Poloniae*, Kraków, 70: 49-79.

Schweigert G., 2006 – A specimen of *Prosopon hebes* v. Meyer, 1840 (Decapoda: Brachyura: Prosopidae) from the Middle Jurassic of SW Germany. *Neues Jahrbuch für Geologie und Paläontologie, Monathshefte*, Stuttgart, 6: 361-370.

Schweitzer C. E., Nyborg T. G. & Feldmann R. M. & Ross R. L. M., 2004 – Homolidae de Haan, 1839 and Homolodromiidae Alcock, 1900 (Crustacea: Decapoda: Brachyura) from the Pacific Northwest of North America and a reassessment of their fossil records. *Journal of Paleontology*, Lawrence, 78 (1): 133-149.

Wehner G., 1988 – Über die Prosopiden (Crustacea, Decapoda) des Jura. Inaugunal - Dissertation zur Erlangung des Doktorgrades der Fakultät für Geowissenschaften der Ludwig-Maximilians-Universität zu München.

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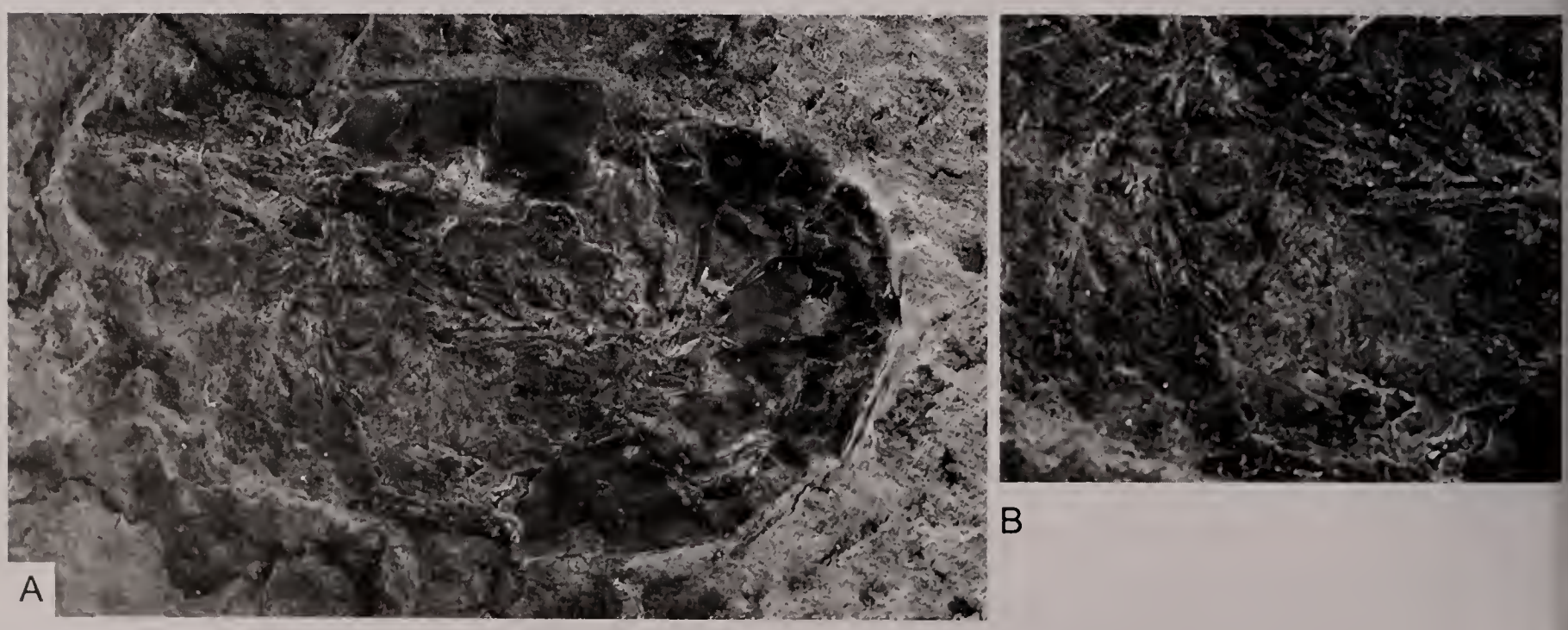
Volume XXXV – Fascicolo II

Cristiano Larghi & Andrea Tintori

First record of a decapod from the Meride Limestone: new data from one of the best Ladinian (Middle Triassic) taphonomic windows of a transitional environment

The Middle Triassic Italian and Swiss localities of Besano-Viggiù (Lombardy) and Monte S. Giorgio-Meride (Canton Ticino) are sites where Triassic marine deposits have been studied through continuous scientific excavations over a period of more than 150 years. The Monte San Giorgio area was included in the World Heritage List of UNESCO in July, 2003, and the Italian authorities are actually working to extend the area to the Italian sites belonging to the same formations. The Triassic sequence is composed of distinct stratigraphical units, the most fossiliferous of which are the upper Anisian-lower Ladinian Besano Formation (or Grenzbitumenzone), and the Ladinian (Middle Triassic) Meride Limestone, the upper levels of which are named Kalkschieferzone by the Swiss authors (Senn, 1924). The sequence records life in a tropical lagoon, sometimes stagnant at the bottom, and hostile to the benthos. The Kalkschieferzone in particular is indicative of a hot climate, subject to seasonal drought with conditions between fully marine or hypersaline and sometimes fresh water; its soft-body fossil biota is the result of a typical taphonomic window of a transitional environment (cfr. Briggs & Gall, 1990). Among the crustaceans of the Kalkschieferzone, besides many specimens of ostracods, conchostracans (Tintori, 1990) and of a new species of a "mysidacean" belonging to *Schimperella*, Bill 1914 (currently under study) only one isolated specimen of decapod has been discovered. The specimen informally named here "*Antrimpos*" sp. n. was collected from the middle levels of the Kalkschieferzone, in the quarry of Ca' del Frate which provided thousands of conchostracans and *Schimperella*. This specimen exhibits features considered by Glaessner (1969) to be diagnostic of *Antrimpos* nevertheless, they are quite common in the basal penaeids, so their value could be limited. Since the erection of *Antrimpos* by Münster (1839), many species of Lower Triassic to Upper Jurassic decapods, often known by incomplete specimens, were ascribed to this genus. Also Glaessner (1969), as other authors before him (e.g. Van Straelen, 1925), considered *Antrimpos* a collective genus, to which many Permo-Triassic to Cretaceous penaeids, not strictly related to modern penaeids, were assigned. As pointed out by several authors (e.g. Garassino & Teruzzi, 1993) the status of this genus should be revised. Garassino & Teruzzi (1995) assigned the Induan (Early Triassic) *A. madagascariensis*, the most ancient species previously attributed to *Antrimpos*, to the new genus *Ifasya*. More recently Schweigert (2001) described evolutionary trends in different populations of *Antrimpos* from the Kimmeridgian and Tithonian (Upper Jurassic) levels of southern Germany, and considered the denticulation of the rostrum and the development of the pereiopods as diagnostic features of the rank of species. "*Antrimpos*" sp. n. from the Kalkschieferzone differs from *Antrimpos noricus* Pinna, 1974, from the Norian (Upper Triassic) Zorzino Limestone (northern Italy) in the larger fourth and fifth pleonites that in *A. noricus* are



Figs. 1 – A) "*Antrimpos*" sp. n. from the Meride Limestone. B) Pereiopods.

very reduced, in the absence of backward protrusion in the posterior margins of pleonites and also in the shortest first pleonite. *Antrimpos atavus*, Bill, 1914, from the Anisian (Middle Triassic) of the northern Vosges, is only known in dorsal preservation (Bill, 1914; Gall, 1971); nevertheless, "*Antrimpos*" sp. n. differs from it in the presence of a gastro-frontal and dorsal ridge, and the more developed pereiopods have robust podomeres. The specimen differs also from *Antrimpos mirigiolensis* Etter, 1994, from the upper Anisian-lower Ladinian Grenzbitumenzone (Monte S. Giorgio, Switzerland), due to the ornaments of the carapace, like the prominent postocular spine, the long spiny rostrum and the different proportions of pleonites. The poorly known *Antrimpos crassipes* (Bronn, 1858) exhibits chelae with bulbous propodi.

References

Bill P. C., 1914 – Über Crustaceen aus dem Voltziensandstein des Elsasses. *Mittheilungen der Geologischen Landesanstalt Elsass-Lothringen*, 8: 289-338.

Briggs D. E. G. & Gall J. C., 1990 – The continuum in soft-bodied biotas from transitional environments: a quantitative comparison of Triassic and Carboniferous Konservat-Lagerstatten. *Paleobiology*, Lawrence, 16 (2): 204-218.

Gall J. C., 1971 – Faunes et paysages du Grès à Voltzia du Nord des Vosges. Essai paléoécologique sur le Buntsandstein supérieur. *Mémoire Service Carte géologique Alsace Lorraine*, Strasburg, 34: 1-318.

Garassino A. & Teruzzi G., 1993 – A new decapod crustacean assemblage from the Upper Triassic of Lombardy (N. Italy). *Paleontologia Lombarda*, Nuova Serie, Milano, 1: 1-27.

Garassino A. & Teruzzi G., 1995 – Studies on the Permo-Trias of Madagascar. 3. The decapod crustaceans of the Ambilobè region (NW Madagascar). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 134 (1): 85-113.

Glaessner M. F., 1969 – Decapoda. In: Treatise on Invertebrate Paleontology. Part. (R). Arthropoda 4. R. C. Moore (ed.). *Geological Society of America*, Lawrence: R399-R651.

Münster G., 1839 – Decapoda Macrura. Abbildungen und Beschreibung der fossilen langschwänzeigen Krebse in den Kalkschiefern von Bayern. *Beiträge zur Petrefactenkunde*, Bayreuth, 2: 1-88.

Schweigert G., 2001 – Eine neue Art der Gattung *Antrimpos* Münster (Crustacea, Decapoda, Penaeidae) aus dem Oberjura Süddeutschlands. *Stuttgarter Beiträge zur Naturkunde*, Stuttgart, B, 307: 1-33.

Senn A., 1924 – Beiträge zur Geologie des Alpensüdrandes zwischen Mendrisio und Varese. *Eclogae geologicae Helvetiae*, 18: 550-632.

Tintori A., 1990 – Estherids from the Kalkschieferzone (Triassic) of Lombardy (N. Italy). Atti del Quarto Simposio di Ecologia e Paleoecologia delle Comunità Bentoniche. Sorrento 1-5 Novembre 1988. *Museo Regionale di Scienze Naturali*, Torino: 95-105.

Van Straelen V., 1925 – Contribution a l'étude de Crustacés Décapodes de la période Jurassique. *Mémoires de l'Académie royale Belgique*, 7.

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Sergio Marangon & Antonio De Angeli

Preservation of some specimens of *Portunus monspeliensis* (A. Milne Edwards, 1860) from the Miocene of Sardinia (Italy)

The Cenozoic decapods from Sardinia have been described by Meneghini (1857), A. Milne Edwards (1860), Parona (1887), Mariani & Parona (1887), Ristori (1888), Lovisato (1902), Lörenthey (1909), Comaschi Caria (1950, 1956), Marras & Ventura (1991), and De Angeli & Marangon (1992). The studied specimens come from marly limestone or calcareous marls from the Oligocene, Miocene, and Pliocene.

Portunus monspeliensis (A. Milne Edwards, 1860) is usually common in the middle Miocene levels of Sardinia and it has been reported by several authors with different synonymies: *Lupa hastata* Linnaeus, 1767, *Neptunus convexus* Ristori, 1888, *N. granulatus* (A. Milne Edwards, 1860) from Cagliari (Monte S. Michele and Fangario), Oristano (Pianu, Magomadas, Flussio, and Tresnuraghes), and Sassari (Bonorva) (Comaschi Caria, 1956). This species is also known from the Miocene of Lecce (Puglia), S. Maria Vigliana (Emilia-Romagna), and Meduno (Friuli-Venezia Giulia) (Ristori, 1888; De Angeli & Garassino, 2006). The presence of *P. monspeliensis* from the Rupelian (lower Oligocene) of Bacino Ligure Piemontese is dubious. In fact, Allasinaz (1987) pointed out that the specimens assigned to this species, discovered in Piedmont, could belong to a different subspecies within *P. monspeliensis*. Finally, this species was also reported from Malta, Spain, Portugal, France, Hungary, Austria, Egypt, and Sinai Peninsula (A. Milne Edwards, 1860; Ristori, 1888; Glaessner, 1928, 1933; Lörenthey & Beurlen, 1929; Müller, 1978, 1984, 1993; Gatt, 2006).

The descriptions and illustrations of this species usually have been made based upon carapaces without exocuticle and therefore the dorsal surface has not the original ornamentation, but a surface with small ovoid tubercles weakly raised that are present in the outer part of the endocuticle.

The specimens from the marly limestone of the Langhian (middle Miocene) of Binu Mancu (the area among the villages of Flussio-Tresnuraghes-Magomadas) provided new contributions to the knowledge of this species. In fact, these specimens show the following morphological characters: original dorsal ornamentation; exocuticle with small granulations, more frequent on metagastric, cardiac, and branchial regions; elongate supraorbital margin and interrupted by two narrow fissures and finely granulate (Fig. 1 D); extraorbital spine more developed than the other seven spines of lateral margin; anterolateral spines decrease in sizes (excluding the elongate spine located on the angle); small granulations also present on the margins of the lateral spines; protogastric regions with transverse granulate crista; epibranchial regions crossed by a sinuous, granulate and transverse crista extending also onto the elongate spine of the anterolateral angle; posterolateral margin concave and with superficial granulate crista; sternite IV with transverse concavity and finely granulate anterior lateral margin (Fig. 1 F). The exocuticle of the carapace, chelipeds, sternites, and abdomen is always of brown-purple colour; many small areas white-yellow in colour are present on chelipeds and surface of carapace (Fig. 1 A-B-C). These areas are larger on the posterior part of the back and smaller and uniform on its other parts. The carapace is brown-purple in colour and the areas are reduced or absent in other specimens. One specimen has the carapace with white exocuticle and chelipeds with brown-purple colour and small areas with white-yellow colour (Fig. 1 G-H).

The colouring of *P. monspeliensis* is similar to that of some Recent portunids, widespread along the American coasts (e. g. *Arenaeus cribrarius* (Lamarck), *Arenaeus mexicanus* (Gerstaecker) exhibiting a carapace of grey or brown colour with small yellow or white areas. The fossil specimens with white carapace (Fig. 1 G) could be a case of albinism. In fact, Rathbun (1930, p. 104) reported occasional examples of albinism in *Callinectes sapidus* Rathbun.

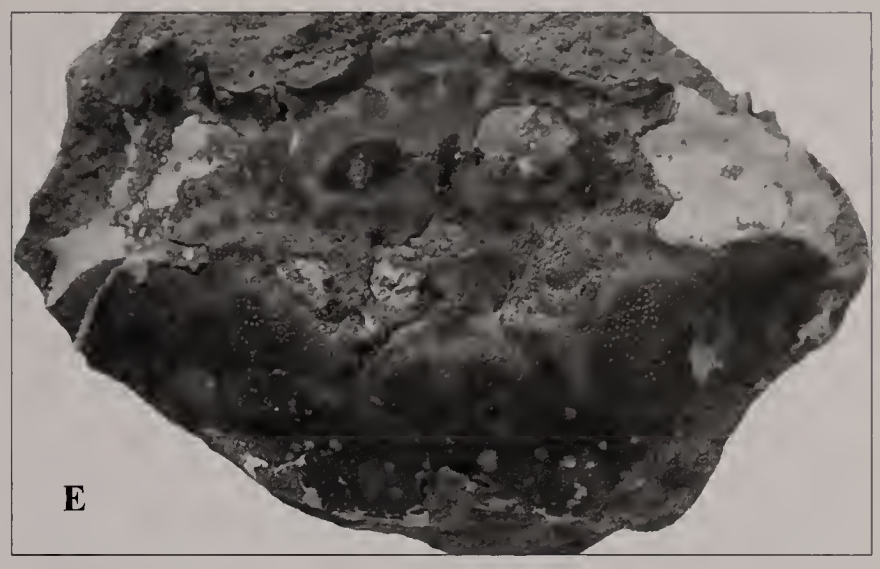
The new specimens of *P. monspeliensis* from the Miocene of Sardinia represent an "*unicum*" in the fossil record because they have preserved the chromatic characters, useful to observe the variations of colour within the same species.

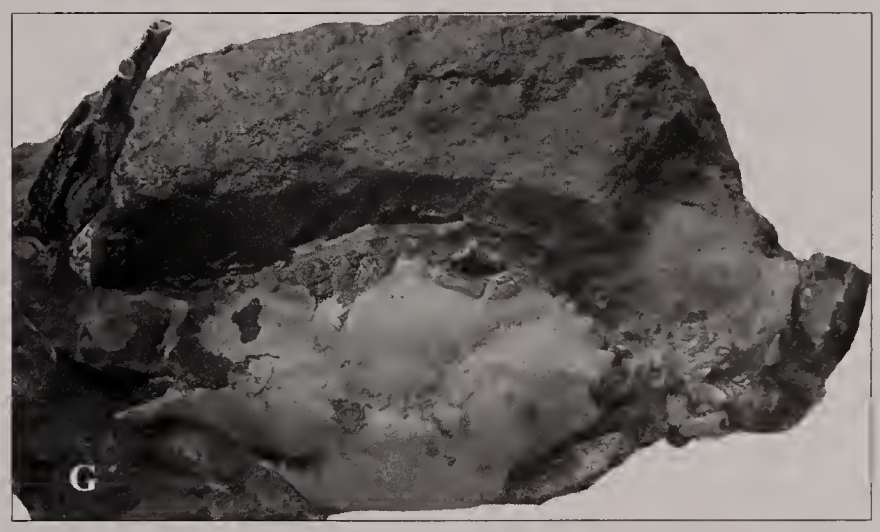
References

Allasinaz A., 1987 – Brachyura decapoda oligocenici (Rupeliano) del Bacino Ligure Piemontese. *Bollettino del Museo regionale di Scienze naturali di Torino*, Torino, 5 (2): 509-566.

Comaschi Caria I., 1950 – Crostacei Decapodi nel Miocene (Elveziano) di Bosa in Sardegna. *Rendiconto del Seminario della Facoltà di Scienze dell'Università di Cagliari*, Cagliari, 20 (3-4): 324-327.

Comaschi Caria I., 1956 – I Crostacei miocenici della Sardegna. *Bollettino del Servizio Geologico d'Italia*, Roma, 78 (1-2): 283-290.





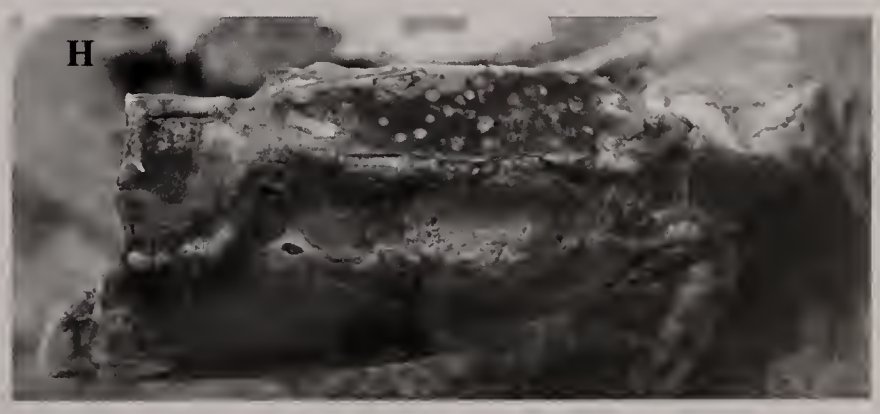


Fig 1 – A-B-C) *Portunus monspeliensis* A. Milne Edwards, 1860, n. cat. MSNM i26874. A-B) Dorsal view. C) Cheliped. D-E) *P. monspeliensis* A. Milne Edwards, 1860, n. cat. MSNM i26875. D) Anterior margin. E) Dorsal view. F) *P. monspeliensis* A. Milne Edwards, 1860, n. cat. MSNM i26876, ventral view. G-H) *P. monspeliensis* A. Milne Edwards, 1860, n. cat. MSNM i26877. G) Dorsal view. H) Cheliped.

De Angeli A. & Marangon S., 1992 – *Necronectes schafferi* Glaessner nel Miocene della Sardegna. *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 17: 175-182.

De Angeli A. & Garassino A., 2006 – New reports of decapod crustaceans from the Mesozoic and Cenozoic of Friuli-Venezia Giulia (NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (2): 267-294.

Gatt M., 2006 – Il-Ġeoloġija u l-Paleontoloġija tal-Gżejjer Maltin - I. *Pubblikazzjonijiet Indipendenza*, Malta.

Glaessner M. F., 1928 – Die Dekapodenfauna des österreichischen Jungtertiärs. *Jahrbuch Geologie Bundesanstein*, Wien, 78 (2): 161-219.

Glaessner M. F., 1933 – New Tertiary Crabs in the Collection of the British Museum. *The Annals and Magazine of Natural History*, London, vol. XII, Tenth series, 67: 1-28.

Lörenthey I. E., 1909 – Beiträge zur tertiären Dekapodenfauna Sardiniens. *Mathematischen und Naturwissenschaftlichen Berichte aus Ungarn*, Budapest, 24: 202-257.

Lörenthey I. E. & Beurlen K., 1929 – Die Fossilen Dekapoden der Länder der ungharischen Krone. *Geologica Hungarica, Serie Paleontologica*, Budapest, 3: 1-420.

Lovisato D., 1902 – Le specie fossili finora trovate nel calcare compatto di Bonaria e S. Bartolomeo. *Tipo-Litografia Commerciale*, Cagliari, 1-21.

Mariani E. & Parona C. F., 1887 – Fossili Tortoniani di Capo S. Marco in Sardegna. *Atti della Società italiana di Scienze naturali*, Milano, 30: 101-191.

Marras G. & Ventura G., 1991 – Crostacei decapodi del Miocene di Sassari (Sardegna nord-occidentale). *Bollettino della Società Sarda di Scienze Naturali*, Sassari, 28: 105-119.

Meneghini G.,1857 – Paléontologie de l'Ile de Sardaigne. In: Voyage en Sardaigne, *Ed. La Marmora*, Torino.

Milne Edwards A., 1860 – Monographie des Décapodes macrures fossiles de la famille des Thalassiniens. *Annales des Sciences Naturelle Zoologie*, Paris, sér. 4, 14: 294-257.

Müller P., 1978 – Decapoda (Crustacea) fauna a budapesti miocénböl (5). *Földtani Közlöny*, Budapest, 108: 272-312.

Müller P., 1984 – A badeni emelet tizlábú rákjai. Decapod Crustacea of the Badenian. *Geologica Hungarica, Serie Paleontologica*, Budapest, 42: 1-121.

Müller P., 1993 – Neogene Decapod Crustaceans from Catalonia. *Scripta Musei Geologici Seminarii Barcinonensis*, Barcelona, 225: 1-39.

Parona C. F., 1887 – Appunti per la Paleontologia miocenica della Sardegna. *Bollettino Società Geologica Italiana*, Roma, 6: 287-358.

Rathbun M. J., 1930 – The cancroid crabs of America of the families Eurylidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae. *United States National Museum Bulletin*, Washington, 152: 1-593

Ristori G., 1888 – Alcuni Crostacei del Miocene medio italiano. *Atti della Società Toscana di Scienze Naturali*, Pisa, 9: 212-219.

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Sergio Marangon & Antonio De Angeli

New decapod assemblage from the lower Oligocene (Rupelian) of Bacino Ligure Piemontese (NW Italy)

The fossil crustaceans from Bacino Ligure Piemontese have been described by several authors. E. Sismonda (1846, 1861) reported some decapods from the Miocene and Pliocene of Asti and Torino. Later, Michelotti (1861), Crema (1895), and above all Ristori (1886, 1889), studied extensively the Oligocene brachyurans of this region. Recently, Allasinaz (1987), Marangon & De Angeli (1997), De Angeli & Marangon (2001, 2003), and Larghi (2003) provided new contributions to the knowledge of the decapod fauna from the Oligocene.

The Oligocene rocks of Bacino Ligure Piemontese lie on a metamorphic formation of continental origin without fossils (Brecce di Cravara). Conglomerates with fossils of plants (Formazione di Pianfolco) are intercalated with these rocks. Transgressive deposits rich in fossils from the middle Rupelian (Formazione di Molare) lie on these conglomerates (Charrier, Fernandez & Malaroda, 1964; Franceschetti, 1967; Bianco, 1985; Balossino & Bianco, 1986; Fantoni, Lovati & Rossi, 1983).

The new specimens (Marangon & De Angeli, work in progress) preserved in nodules of diagenetic origin, come from the middle Rupelian levels (Formazione di Molare) of Case Cherpione (Alessandria). The studied specimens are referred to *Lophoranina aculeata* (A. Milne Edwards, 1881) (Raninidae De Haan, 1839), *Ethusa* n. sp. (Dorippidae MacLeay, 1838), *Retropluma* n. sp. (Retroplumidae Gill, 1894), *Palaeocarpilius aquitanicus* A. Milne Edwards, 1862 (Carpiliidae Ortmann, 1893), and *Asthenognathus* n. sp. (Pinnotheridae De Haan, 1833).

The presence of *Lophoranina* from the Oligocene of Bacino Ligure Piemontese is already known by two carapaces that E. Sismonda (1861) ascribed to *Lophoranina aldrovandii* (Ronzani, 1818). The comparison with the holotype of *L. aldrovandii*, housed in the Museo di Palazzo Poggi, Bologna, and the holotype of *L. aculeata* (A. Milne Edwards, 1881), housed in the Museum national d'Histoire naturelle in Paris, permitted assigning one new specimen and those described by E. Sismonda to *L. aculeata.*

Ethusa n. sp. (Marangon & De Angeli, work in progress) has morphological affinities with *E. chibai* Karasawa, 1993, from the lower Pliocene of Japan which has a narrower cardiac region and less deep branchial grooves. Müller (1984) and Via Boada (1988) reported the presence of one probable new subspecies of *Ethusa mascarone* (Herbst, 1785) from the Messinian (Miocene) of Santa Pola (Alicante, Spain). *Ethusa* n. sp. represents the oldest species known to date in this genus.

Retropluma Gill, 1894, is known from three fossil species: *R. eocenica* Via Boada, 1959 (Ilerdian and Lutetian - Spain and Italy); *Retropluma laurentae* Collins, Lee, Noad, 2003 (Miocene and Pleistocene - Sabah and Sarawak); *R. craveri* (Crema, 1895) (Pliocene - Italy). *Retropluma* n. sp. (Marangon & De Angeli, work in progress) differs from the other species in the shape of the carapace and the ornamentation of the dorsal carinae.

The assignment to *Palaeocarpilius macrochelus* (Desmarest, 1822) of the specimens described by Ristori (1889) and Allasinaz (1987) is dubious. The recent review of the fossil species of *Palaeocarpilius* by Beschin & De Angeli (2006) pointed out the morphological characters that distinguish the Eocene specimens of *P. macrochelus* (Desmarest, 1822) and the Oligocene specimens of *P. aquitanicus* A. Milne Edwards, 1862, by a comparison among the holotypes, housed in the Museum national d'Histoire naturelle, Paris. The new specimen of Case Cherpione is ascribed to *P. aquitanicus* because it exhibits seven anterolateral lobes instead of eight as in the specimens of *P. macrocheilus* (Desmarest, 1822).

Asthenognathus Stimpson, 1858, is known from three Recent and five fossil species: *A. cornishorum* Schweitzer & Feldmann, 1999 (lower Miocene - United States); *A. globosa* (Karasawa, 1990) (lower Miocene - Japan); *A. microspinus* Casadío, De Angeli, Feldmann, Garassino, Hetler, Parrai & Schweitzer, 2004 (Oligocene - Argentina); *A. urretae* Schweitzer & Feldmann, 2001 (upper Oligocene - Argentina); *A. laverdensis* De Angeli & Garassino, 2006 (lower Oligocene - Italy). *Asthenognathus* n. sp. (Marangon & De Angeli, work in progress) has a smooth and subrectangular carapace, differing from *A. laverdensis* in having almost parallel lateral margins and more prominent anterolateral angles (De Angeli & Garassino, 2006).

The faunistic assemblage of Bacino Ligure Piemontese is strictly correlated with the Rupelian faunae of Vicenza (Italy) and Biarritz (France). To date, the species described are the following: *Hoploparia* sp.; *Callianassa* sp.; *Pagurus* sp.; *Callianassa canavari* Ristori, 1889; *Zygopa galantensis* (De Angeli & Marangon, 2001); *Ranina speciosa* (Münster, 1840); *Lophoranina aculeata* (A. Milne Edwards, 1881); *Ethusa* n. sp. (Marangon & De Angeli, work in progress); *Calappa* sp.; *Calappilia mainii* Allasinaz, 1987; *C. vicentina* Fabiani, 1910; *C. verrucosa* A. Milne Edwards, 1873; *Mursiopsis postulosus* Ristori, 1889; *Cherpiocarcinus rostratus* Marangon & De Angeli, 1997; *Retropluma* n. sp. (Marangon & De Angeli, work in progress); *Palaeocarpilius aquitanicus* A. Milne Edwards, 1860; *Portunus convexus* (Ristori, 1889); *Coeloma vigil* A. Milne Edwards, 1865; *Asthenognathus* n. sp. (Marangon & De Angeli, work in progress).

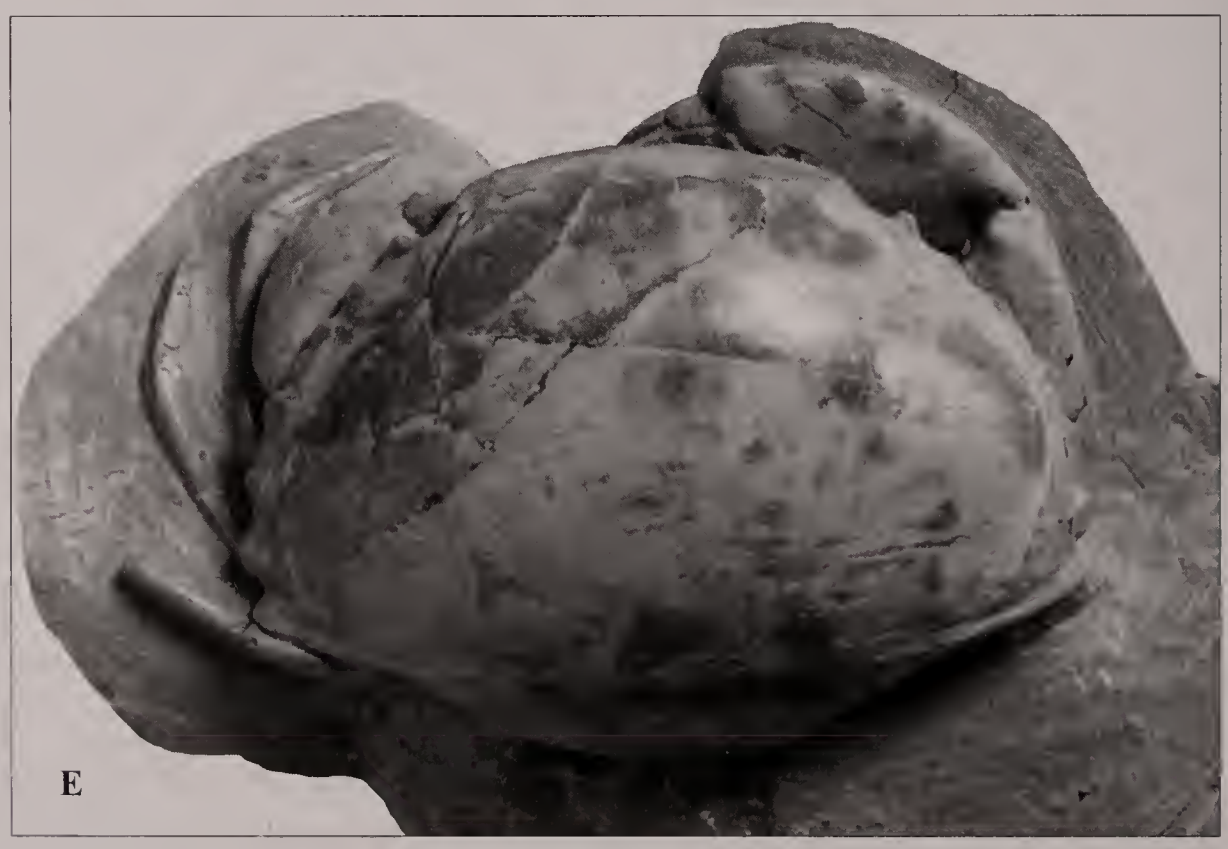

Fig. 1 – A) *Lophoranina aculeata* (A. Milne Edwards, 1881), n. cat. MSNM i26879. B) *Ethusa* n. sp., n. cat. MSNM i26880. C) *Retropluma* n. sp., n. cat. MSNM i26881. D) *Asthenognathus* s. nov., n. cat. MSNM i26882. E) *Palaeocarpilius aquitanicus* A. Milne Edwards, 1860, n. cat. MSNM i26883.

References

Allasinaz A., 1987 – Brachyura Decapoda oligocenici (Rupeliano) del Bacino Ligure Piemontese. *Bollettino del Museo regionale di Scienze naturali di Torino*, Torino, 5 (2): 509-566.

Balossino P. & Bianco P., 1986 – Nota preliminare sulla biostratigrafia dell'area di Ponzone, Cimaferle e Bandita (Piemonte SE). *Bollettino del Museo regionale di Scienze naturali di Torino*, Torino, 4 (2): 469-481.

Beschin C. & De Angeli A., 2006 – Il genere *Palaeocarpilius* A. Milne Edwards, 1862 (Decapoda, Brachyura, Carpiliidae) nel Terziario del Vicentino (Italia settentrionale). *Studi e Ricerche - Associazione Amici del Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (Vicenza), 13: 5-17.

Bianco P., 1985 – Nota preliminare sulla biostratigrafia dell'area di Spigo Monferrato, Pareto e Mioglia (Alpi Liguri, Italia N.O.). *Atti Accademia Nazionale dei Lincei*, Roma, 8, 78: 34-43.

Charrier G., Fernandez D. & Malaroda R., 1964 – La formazione di Pianfolco (Bacino oligocenico Ligure Piemontese). *Atti Accademia Nazionale dei Lincei,* Roma, 87 (2): 25-82.

Crema C., 1895 – Sopra alcuni decapodi terziari del Piemonte. *Atti della Reale Accademia di Scienze di Torino*, Torino, 30: 664-681.

De Angeli A. & Garassino A., 2006 – *Asthenognathus laverdensis* n. sp. (Decapoda: Brachyura: Pinnotheridae) from the lower Oliogecene of Laverda (Vicenza, NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 147 (2): 295-304.

De Angeli A. & Marangon S., 2001 – *Paralbunea galantensis*, nuova specie di anomuro oligocenico del Bacino Ligure-Piemontese (Italia settentrionale). *Studi Trentini di Scienze Naturali, Acta Geologica*, Trento, (1999), 76: 99-105.

De Angeli A. & Marangon S., 2003 – Contributo alla conoscenza dei Decapodi oligocenici del Bacino Ligure Piemontese (Italia settentrionale). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 144 (2): 185-196.

Fantoni R., Lovati I. & Rossi P. M., 1983 – La successione oligocenica tra Ovada e Cassinelle (AL). Evoluzione paleogeografia ed implicazioni strutturali. *Rivista Italiana di Paleontologia*, Roma, 88 (2): 251-270.

Franceschetti B., 1967 – Studi geologici sulla regione ad Ovest di Ovada (Provincia di Alessandria). *Memorie della Società Geologica Italiana*, Roma, 6: 379-420.

Larghi C., 2003 – First record of Oligocene retroplumid crab (Crustacea: Decapoda: Brachyura) from Italy. *Bulletin of the Mizunami Fossil Museum*, Mizunami, 30: 57-60.

Marangon S. & De Angeli A., 1997 – *Cherpiocarcinus*, nuovo genere di brachiuro (Decapoda) dell'Oligocene del Bacino Ligure-Piemontese (Italia settentrionale). *Lavori - Società Veneziana di Scienze Naturali*, Venezia, 22: 97-106.

Michelotti G., 1861 – Etudes sur le Miocène inférieur de l'Italie septentrionale. *Memoire de la Société Hollandais des Sciences*, Harlem.

Müller P., 1984 – Messinian and older decapods from Mediterranean with description of two new species. *Ann. Geol. Pays Helleniques*, Athens, 32: 25-34.

Ristori G., 1886 – I Crostacei Brachiuri e Anomuri del Pliocene italiano. *Bollettino della Società Geologica Italiana*, Roma, 5: 93-129.

Ristori G., 1889 – I Crostacei Piemontesi del Miocene inferiore. *Bollettino della Società Geologica Italiana*, Roma, 7: 397-413.

Sismonda E., 1846 – Descrizione dei Pesci e Crostacei fossili nel Piemonte. *Memorie della Reale Accademia di Scienze di Torino,* Torino, 2 (10): 1-89.

Sismonda E., 1861 – Appendice alla descrizione dei Pesci e Crostacei fossili del Piemonte. *Memorie della Reale Accademia di Scienze di Torino*, Torino, 2 (19): 1-24.

Via Boada L., 1988 – Els decàpodes. In: Història Natural dels Països Catalans, *Enciclopèdia Catalana, S.A.,* Barcellona, 15: 343-352.

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Rafael Gioia Martins-Neto & Sebastião Carlos Dias Júnior

The Brazilian paleodecapod fauna: state of the knowledge

The decapod fauna is well represented in Brazilian deposits with several described species, especially from Cenozoic sediments. Mesozoic decapods are known from the Riachuelo Formation (Lower Cretaceous, Sergipe), Santana Formation (Lower Cretaceous, Ceará), and Itamaracá and Gramame formations (Lower and Upper Cretaceous respectively, Pernambuco). Cenozoic decapods are known from the Maria Farinha Formation (Paleocene, Pernambuco), Cícero Dantas Formation (Eocene/Oligocene, Bahia), Pirabas Formation (Miocene) and Tremembé Formation (Oligocene, São Paulo) (see Martins-Neto, 2005). Recently new species were added: in the Riachuelo Formation (Albian, Sergipe basin) fragments attributable to palinurans were recorded (Reis *et al.*, 2005). Reis *et al.* (2005) suggested a close affinity of one specimen to the family Scyllaridae, and they note as the diagnostic characteristic the presence of three carinae on the cephalic region. Just two families, Coleiidae and Polychelidae, within the Eryonoidea, exhibit three parallel carinae on the dorsal carapace surface, however, neither have recorded genera for the Cretaceous. So, until more complete material is known, this specimen must be considered Eryonoidea family, genus, and species undetermined, possibly new. Apart from this, two species attributed to the genus *Dardanus* were reported in the Paleocene sediments of the Maria Farinha Formation (Távora *et al.*, 2005). For the Pirabas Formation *Calappilia brooksi* Ross & Scolaro, and the species *Arenaeus cribarius* (Lamarck) and *Glyphithyreus sturgeoni* Feldmann *et al.* (Távora *et al.*, 2005) was recorded. A complete list of the known Brazilian decapods is furnished in Table I, updated from Martins-Neto (2005).

Table 1 - Summary of the Brazilian paleocarcinofauna (updated from Martins-Neto, 2005).

Riachuelo Formation (Lower Cretaceous, Sergipe)	
Galatheidae	*Brazilomunida brasiliensis* (Beurlen) Martins-Neto, 2001
Dynomenidae	*Maurimia sergipensis* (Beurlen) Martins-Neto, 2001
Incerta	*Archaeopus rathbunae* Beurlen, 1965
Palinura	Eryonoidea fam. gen. et. sp. indet. (this paper)
Santana Formation (Lower Cretaceous Ceará)	
Palaemonoidea	*Beurlenia araripensis* Martins-Neto & Mezzalira, 1991
Portunoidea	*Araripecarcinus ferreirai* Martins-Neto, 1987
Sergestidae	*Paleomattea deliciosa* Maisey & Carvalho,1995
Itamaracá Formation (Lower Cretaceous, Pernambuco)	
Callianassidae	*Callianassa* sp. Beurlen, 1962
Beberibe Formation (Upper Cretaceous, Pernambuco)	
Callianassidae	*Callianassa beberibae* Beurlen, 1962
Gramame Formation (Upper Cretaceous, Pernambuco)	
Callianassidae	*Callianassa mottai* Beurlen, 1962
	Callianassa massarandubae Beurlen, 1962
Carcineretidae	*Ophthalmoplax brasiliana* (Maury) Beurlen, 1958
Palaeoxanthopsidae	*Palaeoxanthopsis cretacea* (Rathbun) Beurlen, 1958
Maria Farinha Formation (Paleocene, Pernambuco)	
Retroplumidae	*Costacopluma nordestina* Feldmann & Martins-Neto, 1995
	Callianassa sp. Miranda & Távora, 2003
Paguroidea	*Dardanus fucosus* Biffar & Piovenzano; Távora *et al.*, 2005
	Dardanus insignis (Saussure) Távora *et al.*, 2005

Calappidae	*Calappilia brooksi* Ross & Scolaro; Távora *et al.*, 2005
Goneplacidae	*Glyphithyreus sturgeoni* Feldmann *et al.*; Távora *et al.*, 2005
Cícero Dantas Formation (Eocene/Oligocene, Bahia)	
Palaemonoidea	*Bechleja bahiaensis* (Beurlen) Martins-Neto & Mezzalira, 1991
Tremembé Formation (Oligocene, São Paulo)	
Palaemonoidea	*Pseudocaridinella roxoi* (Beurlen) Martins-Neto & Mezzalira, 1991
	Bechleja robusta Martins-Neto & Mezzalira, 1991; Martins-Neto, 1998
	Propalaemon longispinata Martins-Neto & Mezzalira, 1991
	Pseudocaridinella tremembeensis (Beurlen) Martins-Neto & Mezzalira, 1991
Pirabas Formation (Miocene, Pará)	
Calappidae	*Calappilia circularis* (Beurlen) Martins-Neto, 2001
	Acanthocarpus obscurus (Rathbun) Beurlen, 1958
Hepatidae	*Hepatella amazonica* Beurlen, 1958
Leucosiidae	*Typilobus unispinatus* Martins-Neto, 2001
Grapsidae	*Sesarma paraensis* Beurlen, 1958
Atelecyclidae	*Cyclocancer? tuberculatus* Beurlen, 1958
Phartenopidae	*Parthenope trituberculatus* Beurlen, 1958
Portunidae	*Portunus pirabaensis* Martins-Neto, 2001
	Portunus haitensis Rathbun, 1924
	Portunus spinimanus Latreille; Távora & Souza, 2000
	Portunus (Beurlen) Brito, 1972
	Callinectes reticulatus Beurlen, 1958
	Callinectes cf. declivis Rathbun *in* Beurlen, 1958
	Callinectes paraensis Beurlen, 1958
	Scylla costata Rathbun *in* Beurlen, 1958
	Necronectes tajinensis Vega *et al.*; Távora *et al.*, 2002
	Arenaeus cribarius (Lamarck) Távora *et al.*, 2005
	Euphylax septemdentatus Beurlen, 1958
Xanthidae	*Paratumidocarcinus marajoarus* Martins-Neto, 2001
	Panopeus capanemaensis Martins-Neto, 2001
	Tetraxanthus rathbunae Chace; Távora & Souza, 2000
Ocypodidae	*Uca inaciobritoi* Martins-Neto, 2001

The Santana Formation crustaceans (Cretaceous, northeast Brazil) are preserved in an excellent state of preservation, several are complete, articulated, and tridimensional. The fossilization process is due to iron oxide substitution (oxidation) and more rarely apatite (phosphatization). The environment in this case is lacustrine. Another type of lacustrine environment as in the Tremembé Formation (Oligocene, southeast Brazil) isolated cephalothorax pieces as well as fragments of abdomen are found, indicative of several stages of fragmentation. In some specimens the pereiopods still remain articulated, but most parts of the specimens are compacted in the sediment (pirobituminous shale) and the main fossilization process is of the quitine substitution and calcium carbonates by pyrite or marcasite (pyritization). In environments with some marine influence, as is the case of the Romualdo Member (concretion level of the Santana Formation), the crustaceans are fragmented (isolated pieces of cephalothorax and rare abdomen pieces). They are totally disarticulated and preserved as internal moulds. In this specific case, the individual accumulation in a concretion is suggestive of an environmental stress. In the Pirabas Formation (Miocene, north Brazil), the environment is marine and isolated carapaces, some pereiopod, fragments, brachyurans chelipeds, isolated carapaces of lobster-like crustaceans and well preserved pieces in concretions are found. The fossilization process is variable, from moulds to partially permineralized specimens. The majority of these specimens are tridimensional, not articulated and in final steps of fragmentation.

References

Martins-Neto R. G., 2005 – Estágio atual da paleoartropodologia brasileira: hexápodes, miriápodes, crustáceos (Isopoda, Decapoda, Eucrustacea e Copepoda) e quelicerados. *Arquivos do Museu Nacional*, Rio de Janeiro, 63 (3): 471-494.

Reis M. A. F., Turbay C. V. E. & De Cesero P., 2005 – Descrição de um novo Decapoda (Natantia, Malacostraca, Crustácea) da Formação Riachuelo, Albiano da Bacia de Sergipe. *Anuário do Instituto de Geociências - UFRJ*, 28 (1): 80-91.

Távora V. A., Miranda V. F. O., Viegas L. G. F. & Galvão P. H. F., 2005 – Novos registros de crustáceos decápodes do Cenozóico (Paleoceno e Mioceno) do Brasil. *Revista Brasileira de Geociências*, 35 (3): 393-400.

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Volume XXXV – Fascicolo II

Paolo Monaco, Jesús E. Caracuel, Alice Giannetti, Jesús M. Soria & Alfonso Yébenes

Thalassinoides and *Ophiomorpha* as cross-facies trace fossils of crustaceans from shallow-to-deep-water environments: Mesozoic and Tertiary examples from Italy and Spain

The morphological expression of trace fossils varies according to whether they are preserved, within/between sandstone or mudstone beds. For this reason a toponomy has been proposed and a series of terms, the so-called Seilacher's and Martinsson's terms, has arisen to describe the preservation potential of trace fossils. They are: hyporelief or hypichnia (base of bed at boundary), full relief or endichnia (inside bed), full relief or exichnia (outside bed) and epirelief or epichnia (top boundary) (Seilacher, 1964; Martinsson, 1970). Both of these classifications involve structures which are strictly related to the casting medium of an event bed or transition with underlying or overlying beds (Bromley, 1990). Typical expression of hyporelief are graphoglyptids (Fuchs, 1895), a large supergroup of geometrical trace fossils usually preserved at soles of deep-water turbidite deposits of basin plains, which includes a very high diversity of ichnogenera and species (Seilacher, 1977).

Thalassinoides-type branched fossil burrow systems in the geological record, known mainly as *Thalassinoides* and *Ophiomorpha* (chiefly but not exclusively produced by decapod crustaceans), usually are preserved in beds as hypichnia, endichnia and exichnia but their preservation potential and toponomy strictly depend upon the environment and type of event sedimentation. Moreover, the large distribution of these ichnogenera differ from graphoglyptids which are strictly confined to deep water conditions and affecting inter-turbidite muddy deposits (Monaco, in press). *Thalassinoides* and *Ophiomorpha*, therefore, are typical cross-facies trace fossils (Frey *et al.*, 1978), which usually spread in every environments during the Phanerozoic and occur from shallow facies (beach, near-shore and shelf), mainly in the Paleozoic and Mesozoic, to very deep environments (slope to distal basin plains) in the Tertiary (Książkiewicz, 1970; Frey *et al.*, 1978; Palmer, 1978; Archer & Maples, 1984; Sheehan & Schiefelbein, 1984; Bromley, 1990; Fürsich, 1998; Uchman, 1998; Monaco, 2000b; Monaco & Garassino, 2001; Tchoumatchenco & Uchman, 2001; Giannetti & Monaco, 2004). The ichnogenus *Thalassinoides* Ehrenberg (1844) is applied to smooth-walled, essentially cylindrical Y- to T-shaped branched trace fossils. In the Early Jurassic time *Thalassinoides suevicus* (Rieth 1932) characterizes shallow-marine environments as three-dimensional systems of branched, Y-shaped tunnels of variable diameter enlarged at the bifurcation points (Fürsich & Oschmann, 1993; Giannetti & Monaco, 2004). This form is predominantly horizontal, more-or-less regularly branched, essentially cylindrical, and dichotomous bifurcations are more common than T-shaped branches (Howard & Frey, 1984). The origin and palaeoenvironmental significance of *Thalassinoides* has been recently summarised (Howard & Frey, 1984; Ekdale, 1992). Instead, the ichnogenus *Ophiomorpha* Lundgren (1891) commonly occurs as vertical to horizontal or sub-horizontal cylindrical tunnel systems, seldom branched and covered by elongate or irregular pellets arranged perpendicular to the long axis. Branching points are usually preserved in both ichnotaxa but these features are more typical of some ichnospecies (e.g. T. *suevicus*) and reveal sharp angles, locally with characteristic enlargements (Monaco & Giannetti, 2002; Giannetti & Monaco, 2004). Some horizontal segments of *Ophiomorpha*, lacking knobby appearance, resemble typical *Thalassinoides*, but vertical portions are generally lined (Frey *et al.*, 1978; Uchman, 1995; Monaco, 2000). These trace fossils have been generally attributed to the activity of crustaceans, but not only decapods (Frey *et al.*, 1978; Monaco & Garassino, 2001), and their toponomic preservation is here investigated in four cases of event sedimentation from Mesozoic and Cenozoic deposits.

The four case-studied are the follow: A) Lower Jurassic (Pliensbachian) lagoonal limestones and marly beds of the northeastern Prealps (Calcari Grigi); B) Lower Cretaceous inner shelf with unidirectional tractive contour currents, from eastern Spain (Serra Gelada); C) Lower Jurassic outer shelf to basinal nodular deposits with storm/turbidite calcarenites, central Italy (Rosso Ammonitico); D) Miocene slope to basin plain systems with deep water turbidite deposits, northern Apennines (Macigno and Marnoso Arenacea flysch deposits).

A) In lagoonal nodular limestones of the Early Jurassic (Pliensbachian) in northeastern Prealps (Calcari Grigi formation), trace fossils of crustaceans (*Thalassinoides* and *Ophiomorpha*) are very abundant. They are found in limestones forming hexagonal mazes distributed horizontally, and they are particularly well developed at the base of the recorded parasequences: endichnia and hypichnia. In the well-exposed endichnia and hypichnia the maze is regular in shape, branching points exhibit enlargements and the diameter of tunnels decreases progressively from the branched points (diameter varies from 16 to 4 cm). Meshes are horizontal, forming irregular cells up to 30 cm wide, and locally tunnels are randomly distributed in the marls and at the limestone/marl transition at the base of the parasequences. In this case, bioturbation can reach down the marly levels producing nodules suggesting that the trace maker was active to maximize the capture of organic material when the substratum has a low nutri-

tional value (see Giannetti *et al.*, 2007). When tunnels are in the clay or marly levels they are particularly flattened (rare case). Crustacean trace fossils develop at the base of parasequences during rising sea level, indicating that oxygenated and nutrient-rich open marine conditions were induced progressively and are well exploited by crustaceans. In these open marine conditions the high rate of sedimentation, oxygenation, and nutrients are ideal conditions for crustacean burrowing. This new opportunistic fauna populates the lagoon, replacing the oligotrophic fauna (only infaunal bivalves) of restricted and poorly oxygenated conditions typical of the low sea level stand. The arrangement of skeletal grains and peloids in wall structures of thalassinoideans commonly reflects an ichnofabrics of decapod crustacean activity (Giannetti & Monaco, 2004). Structure of the burrow linings and lithified calcareous walls (see type IV) display concentric layering due to crustacean and biogenic stria (see type III and type B of authors), probably related to activity of decapods (Frey *et al.*, 1978; Hasiotis & Mitchell, 1993; Anderson & Droser, 1998; Monaco & Garassino, 2001). In some cases the shape of some non-branched burrows (*Thalassinoides* ? isp.) resembles those of modern stomatopods (Monaco & Giannetti, 2002).

B) In the Lower Cretaceous (Albian) of the Sácaras Formation in the Serra Gelada succession (Prebetic of Alicante, Spain) carbonate-rich, upward thickening inner shelf parasequences were deposited. They are dominated by deposits and features indicating strong currents (maybe contour currents), and many types of trace fossils have been identified (Monaco *et al.*, 2005). Shell-covered, structured trace fossils (*Ereipichnus geladensis*) and unstructured, non-imbricated ones such as *Scolicia* and *Cardioichnus* (produced probably by irregular or heart-shaped spatangoid sea-urchins) and various types of *Thalassinoides* and *Ophiomorpha* have been recorded (Monaco *et al.*, 2005). In this section *Thalassinoides* consists of branched, Y-shaped hypichnia or endichnia, similar to those recovered in Calcari Grigi (mainly type II, III, and IV giant type up to 30 cm in diameter, and type D similar to *Thalassinoides* ?isp., see Giannetti *et al.*, 2007). In some levels a close relationship exists between shell-armoured *Ereipichnus* and large *Thalassinoides* types. Horizontal mazes of this branched endichnia are always distributed deeper (often reaching the hypichnia position) than *Ereipichnus* which tend to occupy shallower tiers to better utilize strong unidirectional currents at the sea-bottom (Monaco *et al.*, 2005). *Thalassinoides*, therefore, develops in deeper tiers when currents at sea-floor are active, and these traces were produced by crustaceans mainly when high sea level conditions occurred (as in the case A). The vertical or oblique *Ophiomorpha,* conversely, develop as endichnia (more properly crossichnia, a new category here introduced to describe trace fossils which cross obliquely two or three beds) exclusively in calcarenites during the lowstand intervals at the top of parasequences. The Serra Gelada section, therefore, is important from the ichnological point of view because a very close relationship exists among current sensitive trace fossils, active bottom currents and sea-level variations in a shallow water environment.

C) The Toarcian Rosso Ammonitico facies in the central Apennines (Italy), was deposited in a relatively shallow (100-150m deep) middle-outer shelf to inner basin, periodically submitted to seaward-oriented tempestites/turbidites (with hummocky cross-stratification). This facies is very rich in small and medium size *Thalassinoides* of types I and II (Monaco *et al.*, 1994; Caracuel *et al.*, 2000). The medium-size Type II has been found as hypichnia at the soles of distal tempestite/turbidite events and develops when calcarenitic material eroded and then deposited on the autochthonous mud (casting). The small Type I, conversely, is more commonly found as endichnia (but also epichnia) mainly close the top of a calcarenite beds (calcilutite) and was subjected to tiering, which represents a vertical partitioning of burrow distribution within the calcarenitic sediment (Caracuel *et al.*, 2000). The shallowest, more oxygenated tier of a typical Rosso Ammonitico tempestite bed, the nodular calcilutite interval, is dominated by small *Thalassinoides* type I, while other minute trace fossils (e.g. *Planolites, Helminthopsis* and *Chondrites*) are distributed at depth in the less oxygenated calcarenite material (Caracuel *et al.*, 2000). A colonisation depth of tiers therefore reflects the new substrate characteristics induced by the event sedimentation. Tiering from reduced (base of bed) to more oxygenated conditions (top of bed) was controlled by the substrate characteristics and by the organic content. The organic matter may be superficially exploited by small crustaceans (one ammonite mould exhibits *Thalassinoides* type I burrow, F. Venturi pers. com.) only when sedimentation rate of unidirectional/oscillatory flow regime decreases to normal conditions. When normal condition re-established (e.g. re-oxygenation) in non-resedimented marls of Rosso Ammonitico facies, then small *Thalassinoides* type I are leaders among other trace fossils and burrowing of shallower tiers (endichnia/epichnia) was very abundant inducing nodularity in the substrate and producing a "gradational" tiering in marls (Caracuel *et al.*, 2000).

D) In Oligo-Miocene siliciclastic deep-water turbidite units of the northern Appennines (central Italy), known as Macigno, Cervarola and Marnoso Arenacea flysch deposits, trace fossils are very abundant and are represented by hypichnia, endichnia, exichnia, epichnia, and crossichnia (if they cross obliquely two or three beds). In thin-bedded, low-density turbidites graphoglyptids (*Paleodictyon* and many others, see Monaco, in press) are exclusively hypichnia, while epichnia groups are formed by totally different traces (e.g. *Scolicia prisca)*. Conversely, in medium to thick-bedded ones (mainly high-density turbidity flow deposits) *Thalassinoides* and *Ophiomorpha* occur as hypichnia, endichnia exichnia (never epichnia), and crossichnia when they cross obliquely the massive sand reaching the underlying marly beds. As indicated by Uchman (1998), the *Ophiomorpha* found in flysch deposits differ from those recovered from shallow water deposits because they commonly occur as small hypichnial specimens which are smooth and straight at the bottom of turbidites (e.g. *O. annulata* and *O. rectus*, see Książkiewicz (1977). Large *Ophiomorpha rudis* (Tunis & Uchman, 2003), is most common in the medium to thick bedded turbidites of Marnoso Arenacea flysch. This very large trace (up to 12 cm in diameter) appears as subhorizontal hypichnia-endichnia in the lower half of the turbidite beds and is characterized by irregular thick ridges, up to 3-4 cm thick, commonly developed as large knobby bulges, with irregular thickening of tunnel diameter. Locally, branches are

very short and represent dead ends. Other forms of high-density turbidites are unbranched and straight, exhibiting a regular thickening of the burrow diameters (twice normal diameter) and producing a typical shape like a car silencer (car silencer-shaped trace fossils). These forms are distributed very commonly (30 specimens preserved at the BIOSEDLAB of Perugia University) as endichnia close to the bottom of meter-thick, sandy turbidites, where they cut giant groove casts at angles up to 60-90°, suggesting adaptative burrowing strategies to high energy and tractive current flows. Other *Ophiomorpha*-like trace fossils are preserved as vertical or oblique, cylindrical, knobby structures, cutting many calcarenite and calcisiltite beds (crossichnia). They are unwalled, sand- or silt-filled, 18-33 mm in diameter reaching up 30 cm in length, and some exichnia/crossichnia specimens show typical ring-shaped, transverse segments (Uchman & Demircan, 1999). Others crossichnia are subquadrate in cross section, revealing regular knobby surfaces, up to 55 mm in diameter and 50 cm in length. These structures were probably not produced by crustaceans. According to (Föllmi & Grimm, 1990), the crustaceans producing *Thalassinoides* and *Ophiomorpha* in deep turbiditic environments may survive transport by turbiditic currents and can produce burrows under anoxic conditions for a limited numbers of days.

The four examples here reported are indicative of cross-facies thalassinoidean trace fossils which are produced by opportunistic organisms. A close relationship probably exists among infaunal activity of crustaceans, event sedimentation, rising of sea level, increasing in the oxygen content and characteristics of the substrate from shallow to deep water conditions where high-density flow or peculiar sedimentary processes occur. Further quantitative analyses are welcome in order to try to define all relationships between these traces and different cases of event sedimentation. The fundamental aim is not only to characterize the toponomy of these important traces, but also to define the palaeoenvironmental features, morphologic expressions (Giannetti *et al.*, 2007) and distribution of crustacean activity in marine substrates.

References

Anderson B. G. & Droser M. L., 1998 – Ichnofabrics and geometric configurations of *Ophiomorpha* within a sequence stratigraphic framework: an example from the Upper Cretaceous US western interior. *Sedimentology*, 45: 379-396.

Archer A. W. & Maples C. G., 1984 – Trace fossil distribution across a marine to non marine gradient in the Pennsylvanian of South Western Indiana. *Journal of Paleontology*, Lawrence, 58: 448-466.

Bromley R. G. C., 1990 – Trace fossils, biology and taphonomy. Special topics in paleontology. *Unwin Hyman Ltd*, London.

Caracuel J., Monaco P. & Olóriz F., 2000 – Taphonomic tools to evaluate sedimentation rates and stratigraphic completeness in Rosso Ammonitico facies (epioceanic tethyan Jurassic). *Rivista Italiana di Paleontologia e Stratigrafia*, Milano, 106 (3): 353-368.

Ehremberg K., 1944 – Ergänzende Bemerkungen zu den seinerzeit aus dem Miozäan von Burgschleinitz beschrieben Gangkernen und Bauten dekapoder Krebse. *Paläontologische Zeitschrift*, Berlin, 23: 345-359.

Ekdale A. A., 1992 – Mudckraking and mudslinging: the joys of deposit-feeding. In: Trace fossils. Short Courses in Paleontology. C. G. Maples & R. R. West (eds.). *The Paleontological Society*, Knoxville, Tennessee.

Föllmi K. B. & Grimm K. A., 1990 – Doomed pioneers: Gravity-flow deposition and bioturbation in marine oxygen-deficient environments. *Geology*, 18: 1069-1072.

Frey R. W., Howard J. D. & Pryor W. A., 1978 – *Ophiomorpha*: its morphologic, taxonomic, and environmental significance. *Palaeogeography Palaeoclimatology Palaeoecology*, Amsterdam, 23: 199-229.

Fuchs T., 1895 – Studien über Fucoiden und Hieroglyphen. *Denkshriften der Kaiserlichen Akademie der Wissenshaften, Wien, Matematisch Naturwissenschaftliche, Klasse*, 62: 369-448.

Fürsich F. T., 1998 – Environmental distribution of trace fossils in the Jurassic of Kachchh (Western India). *Facies*, 39: 243-272.

Fürsich F. T. & Oschmann W., 1993 – Shell beds as tools in basin analysis: the Jurassic of Kachchh, western India. *Journal of the Geological Society*, London, 150: 169-185.

Giannetti A. & Monaco P., 2004 – Burrow decreasing-upward parasequence (BDUP): a case study from the Lower Jurassic of the Trento carbonate platform (southern Alps), Italy. *Rivista Italiana di Paleontologia e Stratigrafia*, Milano, 110 (1): 77-85.

Giannetti A., Monaco P., Caracuel J. E., Soria J. & Yébenes A., 2007 – Functional morphology and ethology of decapod crustaceans gathered by *Thalassinoides* branched burrows in Mesozoic shallow water environments. In: 3rd Symposium on Mesozoic and Cenozoic Decapod Crustaceans. Museo di Storia Naturale di Milano, May 23-25, 2007. A. Garassino, R. M. Feldmann & G. Teruzzi (eds.). *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, XXXV (II): 48-52.

Hasiotis S. T. & Mitchell C. E., 1993 – A comparison of crayfish burrow morphologies: Triassic and Holocene fossil, paleo- and neo-ichnological evidence, and the identification of their burrowing signatures. *Ichnos*, 2: 291-314.

Howard J. D. & Frey R. W., 1984 – Characteristic trace fossils in nearshore to offshore sequences, Upper Cretaceous of east-central Utah. *Canadian Journal Earth Science*, 21: 200-219.

Książkiewicz M., 1970 – Observations on the ichnofauna of the Polish Carpathians. In: Trace Fossils. T. P. Crimes & J. C. Harper (eds.). *Geological Journal Special Issue*, Liverpool.

Książkiewicz M., 1977 – Trace fossils in the flysch of the Polish Carpathians. *Paleontologica Polonica*, Warzawa, 36: 1-208.

Lundgren B., 1891 - Studier öfver fossilförande lösa block. *Geoliska Föreningens Stockholm Förhandlingar*, Stockholm, 13: 111-121.

Martinsson A., 1970 – Toponomy of trace fossils. In: Trace Fossils. T. P. Crimes & J. C. Harper (eds.). *Geological Journal, Special Issue*.

Monaco P., 2000 – Decapod burrows (*Thalassinoides, Ophiomorpha*) and crustacean remains in the Calcari Grigi, lower Jurassic, Trento platform (Italy). 1° workshop on Mesozoic and Tertiary decapod crustaceans. *Studi e Ricerche - Associazione Amici Museo - Museo Civico "G. Zannato"*, Montecchio Maggiore (VI), oct. 4-6, 2000: 55-57.

Monaco P., in press – Taphonomic features of *Paleodictyon* and other graphoglyptid trace fossils in Oligo-Miocene thin-bedded turbidites of Northern Apennines flysch deposits (Italy). *Palaios*.

Monaco P. & Garassino A., 2001 – Burrows and body fossil of decapod crustaceans in the Calcari Grigi, Lower Jurassic, Trento platform (Italy). *Geobios*, Lyon, 34 (3): 291-301.

Monaco P. & Giannetti A., 2002 – Three-dimensional burrow systems and taphofacies in shallowing-upward parasequences, lower Jurassic carbonate platform (Calcari Grigi, Southern Alps, Italy). *Facies*, 47: 57-82.

Monaco P., Giannetti A., Caracuel J. E. & Yébenes A., 2005 – Lower Cretaceous (Albian) shell-armoured and associated echinoid trace fossils from the Sácaras Formation, Serra Gelada area, southeast Spain. *Lethaia*, Oslo, 38: 1-13.

Monaco P., Nocchi M., Ortega-Huertas M., Palomo I., Martinez F. & Chiavini G., 1994 – Depositional trends in the Valdorbia section (Central Italy) during the Early Jurassic, as revealed by micropaleontology, sedimentology and geochemistry. *Eclogae geologicae Helvetiae*, 87 (1): 157-223.

Palmer T. J., 1978 – Burrows at certain omission surfaces on the Middle Ordovician of the Upper Mississippi Valley. *Journal of Paleontology*, Lawrence, 52: 109-117.

Rieth A., 1932 – Neue Funde spongeliomorpher Fucoiden aus dem Jura Schwabens. *Geologische und Paläontologische Abhandlungen*, N.F. 19: 257-294.

Seilacher A., 1964 – Biogenic sedimentary structures. In: Approaches to Paleoecology. J. Imbrie & N. Newell (eds.). *Wiley*, New York.

Seilacher A., 1977 – Pattern analysis of *Paleodictyon* and related trace fossils. In: Trace Fossils 2. T. P. Crimes & J. C. Harper (eds.). *Geological Journal, Special Issue 9*, London.

Sheehan P. M. & Schiefelbein J. D. R., 1984 – The trace fossil *Thalassinoides* from the Upper Ordovician of the eastern Great Basin, deep burrowing in the Early Paleozoic. *Journal of Paleontology*, Lawrence, 58: 440-447.

Tchoumatchenco P. & Uchman A., 2001 – The oldest deep-sea *Ophiomorpha* and *Scolicia* and associated trace fossils from the Upper Jurassic-Lower Cretaceous deep-water turbidite deposits of SW Bulgaria. *Palaeogeography, Palaeoclimatology, Palaeoecology*, Amsterdam, 169: 85-99.

Tunis G. & Uchman A., 2003 – Trace fossils from the Brkini flysch (Eocene), south-western Slovenia. *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 25: 31-45.

Uchman A., 1995 – Taxonomy and paleoecology of flysch trace fossils: the Marnoso-arenacea Formation and associated facies (Miocene, Northern Apennines, Italy). *Beringeria, Heft*, 15: 1- 116.

Uchman A., 1998 – Taxonomy and ethology of flysch trace fossils: revision of the Marian Książkiewicz collection and studies of complementary material. *Annales So-cietatis Geologorum Poloniae*, Kraków, 68: 105-218.

Uchman A. & Demircan H., 1999 – Trace fossils of Miocene deep-sea fan fringe deposits from the Cingoz Formation, southern Turkey. *Annales Societatis Geologorum Poloniae*, Warzawa, 69: 125-135.

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Carlos Neto de Carvalho & Pedro Andrade E. J. Viegas

Microfacies analysis of *Thalassinoides* infilling: causes of collective burial among *Mecochirus* populations

Decapod ichnofossils are the commonest ones in the stratigraphic record of Portugal. Among them, *Thalassinoides* dominates the lagoonal and inner shelf facies from the late Sinemurian (Duarte *et al.* 2006) to Messinian (Cachão *et al.* 2000) of west Iberia defining, many times, the entire carbonate sequence with its "nodular" fabric. However, as usual all over the world, the decapod producer and their burrows almost never are found preserved together, allowing identification of the decapod *modus vivendi.* Recently, Neto de Carvalho *et al.* (2007) described an unit with burrow mazes of *Thalassinoides suevicus* (Rieth, 1932) with hundreds of *Mecochirus rapax* (Harbort, 1905) as an *obrution lagerstätte*, in the lower Barremian from the Lusitanian Basin. Those lobsters show an exceptionally complete preservation of the thin carapace including the first pereiopods reaching 12 cm, as well as all the ornamentation details of the cephalotorax and pereiopods. *Mecochirus* are usually enrolled in the *rigor mortis* position (Fig. 1a) and are laterally deposited close to the floor of the burrows. The environmental causes that lead to the collective and instantaneous entombment of *Mecochirus* populations within their burrow systems, repeated several times during as much as 1 Ma (Rey, 1993), apparently never to happen again in all the Lusitanian basin is unknown.

The *Mecochirus-Thalassinoides* association occurs in a Lower Cretaceous sequence of mixed sedimentary shelf, carbonate and siliciclastic sediments (Rey, 1993). Fossils crop out, along more than 700 m on a monoclinal 15° north-dipping sequence, without evidence of important tectonic or strong diagenetic imprint. Assigned to the top of the lower Barremian (Rey, 1972), the Boca do Chapim Formation is composed of marly limestones that are dominated in the first meters by poorly sorted, subangular quartz grains, less than 4 cm, and bioclastic at the top, with subordinate intercalations of argillaceous marls. The *Thalassinoides* ichnoguild and benthic fauna found in the Boca do Chapim Formation indicate a back-reef lagoon in a shallow subtidal setting (cf. Rey, 1972; Neto de Carvalho *et al.* 2007), with episodic coarse influxes from a proximal fluvial braided system (Fig. 1b). In fact, to the east, the Boca do Chapim Formation interfingers with a siliciclastic complex of fluvial origin. Microfacies analysis of *Thalassinoides* fill permits description of the paleoenvironmental events responsible for death and complete preservation of *Mecochirus* without evidences of scavenging or decay. Thin section analysis revealed 4 microfacies, all defined by the absence of abundant organic remains (wood fragments) or pyrite, indicators of anoxia. Curiously, *Favreina* was not reported which could be the result of a predatory feeding habit for the producer and a frequent interaction with the marine bottom. Microfacies #1 is composed of biomicrite with abundant shell fragments and dasycladaceans. On the other hand, microfacies #2 is formed by intramicrite (Fig. 1c). Both microfacies have little fine grained siliciclastics and almost no *Choffatella.* These are evidences for a rapid infilling of *Thalassinoides* with dense mud and pelleted mud flows from the surroundings during storm events or strong tidal currents. Biomicrites with *Choffatella* from the intermediary microfacies #3 (Fig. 1d), show more influence from coastal sediments. On the other hand, microfacies #4, composed of biomicrites, wackestones, and intrabiomicrosparites packstones (Fig. 1e), reveals abundant heterogranular siliciclastics (abundant quartz and quartzite, angular to sub-rounded grains not more than 5 mm long). This microfacies indicates episodic flows of coarse sediment from the coast and the fluvial braided system (with contributions from alluvial fans) nearby the lagoon sector (Fig. 1f), leading to successive smothering of *Mecochirus* by the flood runoff with sudden changes in the water chemistry (<salinity, <pH) within *Thalassinoides*.

References

Cachão M., de Gibert J. M., Mayoral E., Muñiz F. & da Silva C. M., 2000 – Paleoicnologia da Formação de Cacela (Miocénio Superior), Algarve, Portugal: dados preliminares. *I Congresso Ibérico de Paleontologia/XVI Jornadas de la Sociedad Española de Paleontologia*, Évora: 5-7.

Duarte L. V., Perilli N., Antonioli L., Rodrigues R., Cabral M. C., Dino R. & Azerêdo A. C., 2006 – Evidências sedimentológicas, geoquímicas (COT) e micropaleontológicas nas fácies betuminosas do Sinemuriano terminal de Água de Madeiros (Portugal). J. Mirão & A. Balbino (eds.). *VII Congresso Nacional de Geologia, Livro de Resumos,* Évora, 2: 633-636.

Neto de Carvalho C., Viegas, P. A. & Cachão, M., 2007 – *Thalassinoides* and its Producer: Populations of *Mecochirus* Buried within their Burrow Systems, Boca do Chapim Formation (Lower Cretaceous), Portugal. *Palaios*, 22: 107-112.

Rey J., 1972 – Recherches géologiques sur le Crétacé Inférieur de L'Estremadura (Portugal). *Memórias dos Serviços Geológicos de Portugal*, 21: 1-477.

Rey J., 1993 – Stratigraphie séquentielle sur une plateforme à sédimentation mixte: exemple du Crétacé inférieur du Bassin Lusitanien. *Comunicações dos Serviços Geológicos de Portugal*, 79: 87-97.

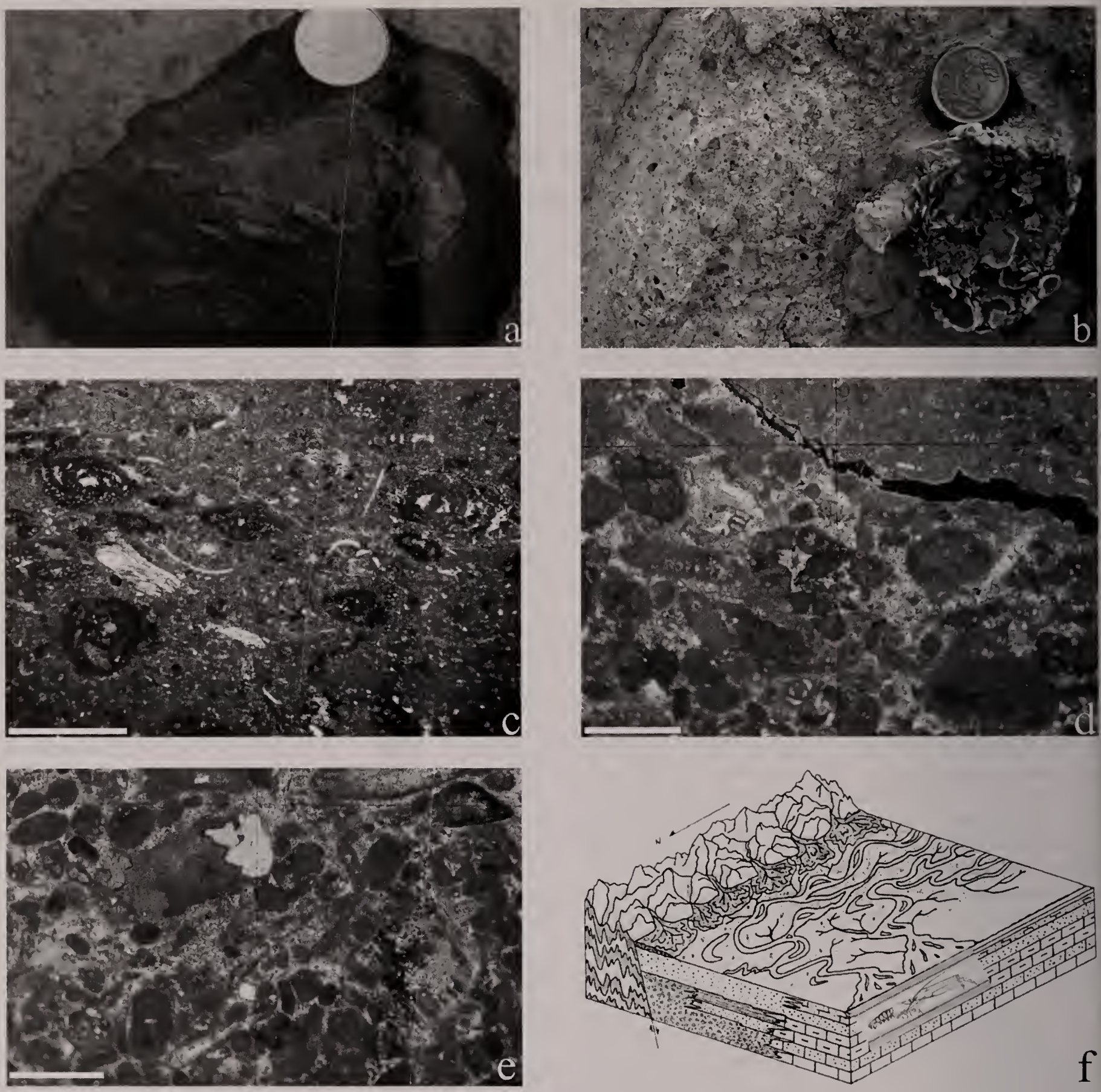

Fig. 1 - Thin sections analysis of the *Thalassinoides suevicus* fill that shrouded *Mecochirus rapax* in the obrutionary deposits from Boca do Chapim Formation. a) *Mecochirus* in *rigore mortis* showing details of ornamentation; coin = 24 mm. b) Coarse quartzarenite fill of *Thalassinoides suevicus* in brackish-water intertidal sandy bars; coin = 22 mm. c) *Thalassinoides* fill of microfacies #2 type (intramicrosparite), with large muddy clasts and Miliolidae. Compare with the micritic matrix (top right). d) Biomicrite with *Choffatella* (microfacies #3) and the surrounding matrix (mudstone). Note the lack of burrow wall. e) Microfacies #4: Intrabiomicrosparite packstone with sub-rounded quartzite grains showing a metamorphic (Variscan) source for the siliciclastics. Bar scale = 0,5 mm. f) Paleogeographic reconstitution of the studied area during the Lower Cretaceous. Artwork of Nuno Dias and Carlos Farinha.

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Cristina M. Robins, Rodney M. Feldmann & Carrie E. Schweitzer

Primitive brachyurans and galatheids from Ernstbrunn, Austria: an evaluation of the Friedrich Bachmayer Collection

The Friedrich Bachmayer Collection, housed in the Natural History Museum of Vienna, Austria, contains many specimens of primitive brachyurans and galatheids from the Upper Jurassic (Tithonian) of Ernstbrunn, Austria. Over 130 specimens, a small fraction of his extensive collection, were selected and studied based on their excellent preservation and unique characteristics. Special effort was made to choose specimens that contained appendages, particularly chelae, or possible ventral carapace surfaces.

The geology of the Ernstbrunn area has been extensively studied for both paleontological and tectonic reasons (Zeiss, 2001; Adámek, 2005). The Ernstbrunn Limestone reaches 120 m in thickness (Adámek, 2005) and is sandwiched between the Waschberg Zone and the Molasse Basin (Zeiss, 2001). Stratigraphically, the Ernstbrunn Limestone is unconformably below the Klement Formation and conformably overlies the Klentnice Formation (Zeiss, 2001). It crops out in several locations in northern Austria and the Czech Republic (Zeiss, 2001; Adámek, 2005). It caps the Malmian sedimentation sequence, a basinal pelagic-carbonate to marginal carbonate sequence that was most likely deposited during the Tithonian (Adámek, 2005). In addition to crustaceans, fossils found in the Ernstbrunn Limestone include foraminifera, green algae, sponges, hydrozoans, corals, cephalopods, bryozoans, brachiopods, mollusks, and echinoderms, isopods as well as fish (Zeiss, 2001; Adámek, 2005). Given the presence of both coral and algal fossils, the Ernstbrunn Limestone was deposited within the photic zone. Bachmayer (1947) hypothesized that the crustaceans he studied lived on a reef talus slope. Zeiss (2001) agreed in part, but offered a hypothesis of a lagoonal setting that opened up into a marine reef environment.

During the lower Miocene the Carpathian orogeny caused tilting and uplift within this area (Zeiss, 2001; Adámek, 2005). Subsequent tectonic events have buried much of the Jurassic units in this area underneath a thick series of flysch deposits. Thus, outcrops are limited and much of the information about the Ernstbrunn Limestone was taken from drill-core samples (Adámek, 2005).

The Ernstbrunn Limestone has been quarried for use as a building rock; also, since it is so pure, it is used for making plaster. Castle Staatz and Castle Falkenstein (now ruins) were constructed from the Ernstbrunn Limestone (Zeiss, 2001).

All but two of the selected decapod specimens are preserved within white, fine-grained crystalline limestone. Bachmayer (1947) described several localities where he found crustacean specimens, including an abandoned quarry near Ernstbrunn, Austria, which contained white, fine-grained limestone that yielded many crustacean fossils. It appears that this quarry is still accessible. It is possible the fossils are from this locality, as it is the only one he described that is both fossil-rich and of white limestone. However, Bachmayer also noted that whereas most of the specimens found at Ernstbrunn were very similar or identical to those found in Stramberg, now in the Czech Republic, the ones from Ernstbrunn were barely half the size of the ones from Stramberg. Given the relatively large size of the individuals within this collection, it is possible that some of the fossils originated from Stramberg, Czech Republic, and are mixed in with the Ernstbrunn fossils.

The majority of the studied specimens are from the superfamily Galatheidea Samouelle, 1819, and primitive brachyurans that are members of the families Prosopidae von Meyer, 1860, and Goniodromitidae Beurlen, 1932 (synonym Pithonotidae Glaessner, 1933), both of which are considered key to understanding the evolution of brachyurans (Müller *et al.*, 2000; Feldmann *et al.*, 2006). In many specimens, all that remains of the dorsal carapace is a thin chalky layer; however, fine details of ornamentation and other morphological features are visible. Unfortunately, similar to other known Jurassic brachyurans, none of the specimens is articulated. While there are numerous disarticulated appendages and chelae among the specimens, no definitive associations between chelae and individual species can be made.

The comparatively excellent preservation and variety of these specimens allows detailed study of decapods that are not widely documented within the fossil record. Based on the high quality of preservation and conclusions from previous work on the paleogeography and paleoenvironment of the Late Jurassic (Bachmayer, 1947; Müller *et al.*, 2000; Feldmann *et al.*, 2006), it is concluded that the specimens were preserved in a coral-dominant reef setting typical of the Tithonian.

References

Adámek J., 2005 – The Jurassic floor of the Bohemian Massif in Moravia-geology and paleogeography. *Bulletin of Geosciences, Czech Geological Survey*, Brno, 80: 291-305.

Bachmayer F., 1947 – Die Crustaceen aus dem Ernstbrunner Kalk der Jura-Klippenzone zwischen Donau und Thaya. *Jahrbuch der Geologischen Bundesanstalt*, Vienna, 8: 35-47.

Beurlen K., 1932 – Brachyurenreste aus dem Lias von Bornholm mit Beiträgen zur Phylogenie und Systematik der Brachyuren Dekapoden. *Paläontologische Zeitschrift*, Stuttgart. 14: 52-66.

Feldmann R. M., Lazăr I. & Schweitzer C. E., 2006 – New crabs (Decapoda: Brachyura: Prosopidae) from Jurassic (Oxfordian) sponge bioherms of Dobrogea, Romania. *Bulletin of the Mizunami Fossil Museum*, Mizunami, Japan, 33: 1-20.

Glaessner M. F., 1933 – Die Krabben der Jura-Formation. *Zentralblatt für Mineralogie, Geologie und Palaontologie*, Stuttgart. Abt. B: 178-191.

Müller P., Krobicki M. & Wehner G., 2000 – Jurassic and Cretaceous primitive crabs of the Family Prosopidae (Decapoda: Brachyura). Their taxonomy, ecology and biogeography. *Annales Societatis Geologorum Poloniae*, Kraków, 70: 49-79.

Meyer H. von, 1860 – Die Prosoponiden oder die Familie der Maskenkrebse. *Palaeontographica*, Stuttgart, 7, 183-222.

Samouelle G., 1819 – The Entomologist's Useful Compendium, or An Introduction to the Knowledge of British Insects. *Thomas Boys*, London.

Zeiss A., 2001 – Die Ammonitenfauna der Tithonklippen von Ernstbrunn, Niederösterreich. *Neue Denkschriften des Naturhistorischen Museums in Wien*, Vienna: 14-26.

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Günter Schweigert

Preservation of decapod crustaceans in the Upper Jurassic lithographic limestones of southern Germany

The lithographic limestones in the Upper Jurassic of southern Germany belong to the most important Fossillagerstätten concerning not only vertebrates but also the fossil record of decapod crustaceans in the Jurassic and even in the whole Mesozoic. There are numerous sites in this region, often generalized and labelled as "Solnhofen", but in fact coming from various localities (e.g. Brunn, Daiting, Eichstätt, Hienheim, Langenaltheim, Mörnsheim, Nusplingen, Painten, Pfalzpaint, Schamhaupten, Solnhofen, Wattendorf, Zandt, Fig. 1A) in a large area and spanning the time interval from the Late Kimmeridgian to the Early Tithonian (Schweigert & Garassino, 2003; Garassino & Schweigert, 2006; Schweigert, in press). Only very few of these localities did not yield any crustaceans, possibly due to unfavourable preservation conditions during earliest diagenesis.

Formerly the focus of the scientific interest lay almost exclusively in the description of taxa and was still very successful in the last decade because of several scientific excavations (Brunn, Nusplingen, Schamhaupten, Wattendorf), intensive evaluation of older collections, enhanced quality of preparation and new preparation techniques, and the use of ultraviolet illumination for detailed anatomical studies (Polz, 1999, 2000; Garassino & Schweigert, 2006; Schweigert 2001a, b, c, 2002, 2003; Schweigert *et al.*, 2000; Schweigert & Garassino, 2004, 2005a, b, 2006). Palaeoecological or functional analyses of decapod crustaceans from the lithographic limestones have been mostly neglected in the past. To date c. 85 valid taxa have been reported – younger synonyms, juveniles or sexual dimorphs not included. Still three to four completely new taxa appear from the quarries every year. However, this high number is summarized from the various localities which have different lithologies and ages. In the distribution of taxa significant local differences exist, probably due to different ecologies in the surroundings.

At present we try to reconstruct the former habitats in which decapods lived and the circumstances of their burial. The bulk of crustacean fossils, lobsters as well as shrimps and prawns, are not true "body fossils" but exuviae. In most cases the exuviae can be easily recognized by their strong compaction, whereas in body fossils there is still a remarkable relief and often a phosphatic preservation of the soft tissue present (Briggs *et al.*, 2005). Sometimes exuviae also differ significantly from "body fossils" in their orientation. Moreover, exuviae often show typical disaggregating, like incomplete articles, a dorsally opened carapace and, after longer time of drifting, numerous nematode borings. A common preservational state of many eryonids shows their pereiopods I pointing backward. This was caused by anchoring of the heavy chelae hanging down from the drifting exuvia (Fig. 2A). During decay the carapace of eryonids splits off in the dorsomedian line suggesting a much broader carapace than in reality. In the past this phenomenon has led to erroneous reconstructions and/or the erection of synonymous taxa.

The co-occurrence of different ontogenetic stages of a single palaeobiospecies suggests an identity of the habitat and the place of burial, or at least a closest neighbourhood. In the lithographic limestones in the vicinity of Eichstätt this is true for several shrimps and prawns (*Aeger* Münster, 1839, *Antrimpos* Münster, 1839, *Hefriga* Münster, 1839). Most other taxa, however, are very rare or even only known by unique specimens (Schweigert, 2002; Schweigert & Garassino, 2004, 2005a, b). They also mostly represent exuviae. For this reason it is assumed that they must have lived in more distant areas, and their record often depended on random circumstances. More data about their former habitats and life styles are available from a functional analysis, e.g. of the chelae. Among shrimps there are typical detritus feeders with pincer-like chelae (e.g. *Blaculla* Münster, 1839, *Dusa* Münster, 1839) which must have lived in reefal habitats. Brachyurans (prosopids, galatheids) often occur in Upper Jurassic sponge-microbial reefs or adjacent bedded limestones (Müller *et al.*, 2000), whereas they are extremely rare within the lithographic limestones (e.g. Öchselberg near Breitenhill, Garassino *et al.*, 2005). Anomurans (e.g. *Magila* Münster, 1839) are common in calcareous, bioturbated deposits, but also very rarely recorded from lithographic limestones. Interestingly, some of the Late Jurassic anomuran taxa are only recorded from the lithographic limestones, and not from coeval bioturbated basin deposits (e.g. *Etallonia* Oppel, 1861, *Megachela* Schweigert, 2003). Possibly anomurans are often overlooked due to their poor sclerotization and preservation and small size (Polz, 1999; Schweigert, 2003).

Endobenthic decapods like glypheids occur frequently (Polz, 2000; Schweigert & Garassino, 2005a, 2006), but almost exclusively as exuviae. Notably there are some local occurrences, like that of *Glyphea saemanni* Oppel within the lithographic limestone of Brunn in eastern Bavaria (Röper *et al.*, 1996). The latter was originally described from the famous locality of Cerin (Dpt. Ain, France), thus pointing to a special ecological niche being present in both localities. The thalassinoid burrows of glypheids (*Spongeliomorpha*) are recorded from only a few localities (Brunn, Nusplingen) but yet without in-situ findings.

Epibenthic lobsters which exhibit strong chelae, like erymids (*Eryma* v. Meyer, 1840, *Erymastacus* Beurlen, 1928, *Palaeastacus* Bell, 1850, *Pustulina* Quenstdt, 1857), are significantly more common in localities in which also other benthic organisms occur (e.g. Zandt).

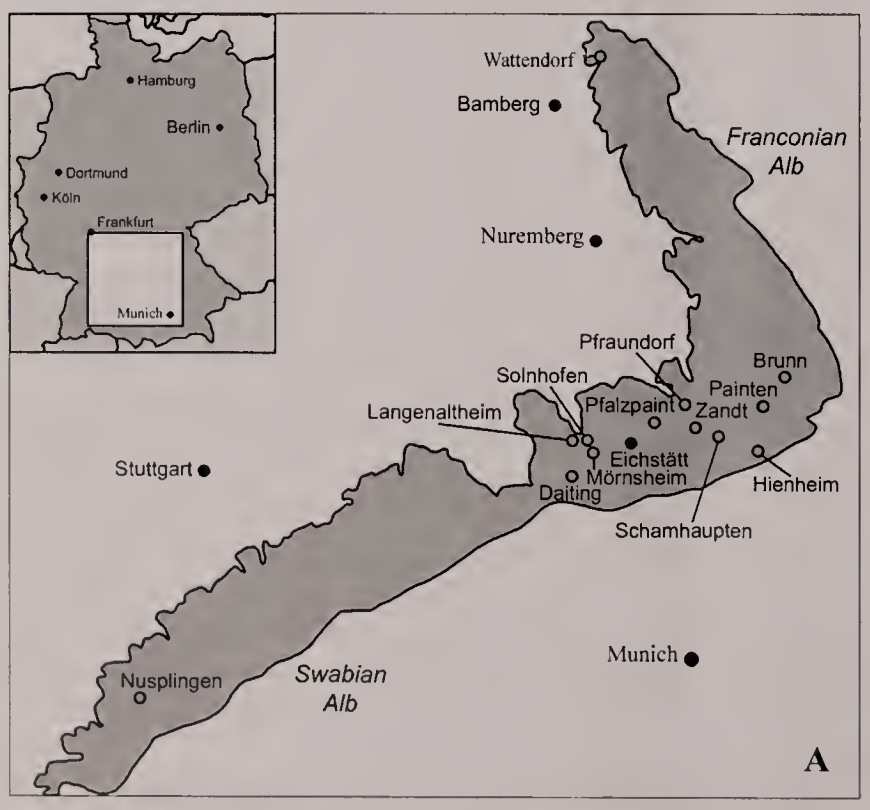
This is especially the case concerning adult specimens.

An autochthonous occurrence can be proved by the record of interactions between the animals and the substrate. A good example is the prawn *Antrimpos undenarius* Schweigert, 2001, which is the most frequent decapod in the small but rather deep lagoon of Nusplingen in the western part of the Swabian Alb (Fig. 1A; Schweigert, 2001b). Besides exuviae there are plenty of specimens deadly injured by predators (c. 50 % of all specimens), and often they left their arrow-shaped last traces on the seafloor (*Telsonichnus* Schweigert, 1998), produced by the tail fan (Schweigert, 1998, 2001b; Schweigert & Dietl, 2005). Mass occurrences of small, comma-shaped coprolites with plant debris might also stem from this prawn that obviously lived in great abundance in this lagoon. Remains of *Antrimpos undenarius* Schweigert, 2001, are recorded as the prey of nautilids, fishes, and teuthoid squids. Interestingly, in the Nusplingen Lithographic Limestone the juveniles or larva of *Antrimpos* are lacking. Most likely they did not live in the lagoon but somewhere else. Such juvenile shrimps and prawns are quite frequent on some bedding planes in the Eichstätt area (e.g. "*Bombur complicatus*" by Münster, 1839). Resting traces of palinurids (*Tripartichnus* Vallon & Röper, 2006) occur in the lithographic limestones of Walting near Pfalzpaint, whereas the animals themselves are lacking there (Vallon & Röper, 2006).

A passive input of crustacean remains (e.g. isolated chelae) by predators is important in small lagoons like that of Nusplingen (Schweigert *et al.,* 2000). But there are even some rare examples of benthic decapods probably sunken down from drifting wood to the seafloor (Fig. 1B). Several recent findings of the common reptant *Mecochirus longimanatus* (Schlotheim, 1820) from the Solnhofen Lithographic Limestone of Langenaltheim are spectacular. They show the act of moulting preserved on the bedding plane (Fig. 2B) and some examples will be described in detail elsewhere. Because of the general of lack of bioturbation, the lithographic limestones are often said to have been deposited in a restricted environment, uncomfortable for higher organisms. For the main reasons, either oxygen depletion or hypersaline brines are discussed. However, for several specialized taxa, like *Mecochirus* Germar, 1927, life conditions on the sea floor were tolerable at least temporarily. Some of the benthic eryonids show adaptations to soft substrates, especially in *Eryon arctiformis* (Schlotheim, 1820). Similar to *Mecochirus* (cf. Oppel, 1862, Pl. 23, figs. 1-2) its carapace and parts of the appendages exhibit a broad fringed margin composed of fine setae. This could either be interpreted as a "snowshoe effect" hampering the sinking into the soft ground, or the respiration was enhanced by the enormous enlargement of the body surface thus enabling the dwelling in somewhat low-oxygen environments. The fringed margin is only preserved in specimens which were immediately buried during rapid sedimentation events, but usually not in exuviae. Other eryonids (e.g. *Cycleryon* Glaessner, 1965) exhibit large stalked eyes pointing to coarser substrates which allowed the animals a shallow trenching, waiting for prey.

Also in the very rare caridean shrimp *Pleopteryx kuempeli* Schweigert & Garassino, 2004, an adaptation to low-oxygen conditions was recently suggested, because of enigmatic, very large feather-like pleopodal appendages developed, unknown from any Recent genus (Schweigert & Garassino, 2004, 2006). The relative abundance of this taxon in a small area in the northern vicinity of Eichstätt (Wintershof) points to a close distance from the place of burial to the original habitat of this shrimp.

Summarizing the above observations, it can be stated that there are only a few specialized crustaceans living in the same area in which the lithographic limestones were deposited. However, the bulk of decapod crustacean taxa recorded from the lithographic limestones must be regarded as allochthonous.



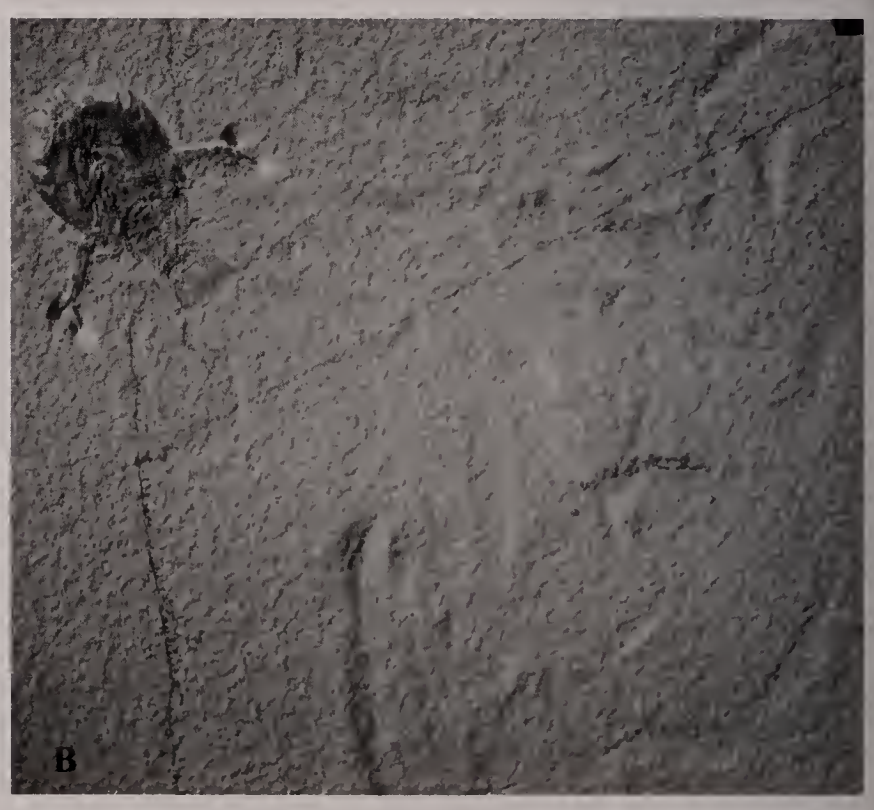


Fig. 1 - A) Sites of lithographic limestones in southern Germany which contain decapod crustaceans (from Fürsich *et al.*, in press, slightly modified). B) *Eryon arctiformis* (Schlotheim, 1820). Specimen probably sunken from drifting wood to the seafloor, with the ventral side upwards. Solnhofen Lithographic Limestone, Langenaltheim near Solnhofen, *Hybonotum* Zone; Jura-Museum Eichstätt, no. JME-SOS 6816a. Length of specimen c. 82 mm.

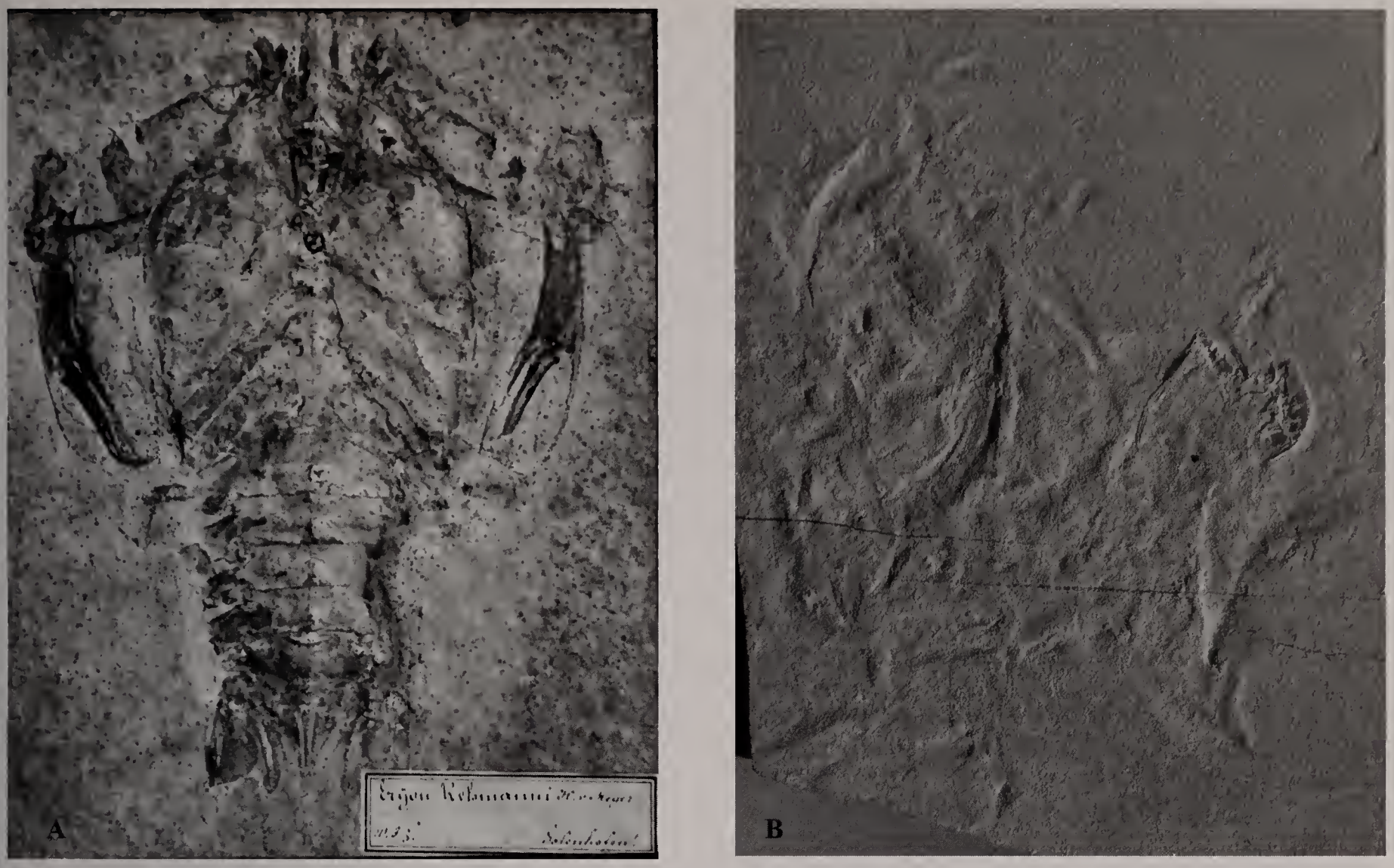


Fig. 2 - A) *Cycleryon propinquus* (Schlotheim, 1822) (= type specimen of *Eryon rehmanni* v. Meyer, 1838). Solnhofen Lithographic Limestone, vicinity of Solnhofen; Lower Tithonian, *Hybonotum* Zone; Fürstlich-Fürstenbergische Sammlung Donaueschingen, no. Pz 2799.1. Length of specimen c. 170 mm. B) *Mecochirus longimanatus* (Schlotheim, 1820), exuvia lacking the carapace, with traces of the moulting. Solnhofen Lithographic Limestone, Langenaltheim near Solnhofen, *Hybonotum* Zone; Staatliches Museum für Naturkunde Stuttgart, no. 23262. Length of specimen c. 60 mm.

References

Briggs D. E. G., Moore R., Shultz J. W. & Schweigert G., 2005 – Mineralization of soft-part anatomy and invading microbes in the horseshoe crab *Mesolimulus* from the Upper Jurassic Lagerstätte of Nusplingen, Germany. *Proceedings of the Royal Society of London*, series B, London, 272: 627-632.

Fürsich F. T., Mäuser M., Schneider S. & Werner W., in press – The Wattendorf Plattenkalk (Upper Kimmeridgian) – a new conservation lagerstätte from the northern Franconian Alb, southern Germany. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, Stuttgart.

Garassino A., De Angeli A. & Schweigert G., 2005 – Brachyurans from the Upper Jurassic (Kimmeridgian - Tithonian) lithographic limestones of Pfalzpaint and Breitenhill (Bavaria, S Germany). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, Milano, 146 (1): 69-78.

Garassino A. & Schweigert G., 2006 – The Upper Jurassic Solnhofen decapod crustacean fauna: review of the types from old descriptions. Part I. Infraorders Astacidea, Thalassinidea, and Palinura. *Memorie della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 34 (1): 1-64.

Müller P., Krobicki M. & Wehner, G., 2000 – Jurassic and Cretaceous primitive crabs of the family Prosopidae (Decapoda: Brachyura) - their taxonomy, ecology and biogeography. *Annales Societatis Geologorum Poloniae*, Kraków, 70: 49-79.

Münster, G. Graf zu, 1839 – Decapoda Macroura. Abbildung und Beschreibung der fossilen langschwänzigen Krebse in den Kalkschiefern von Bayern. *Beiträge zur Petrefactenkunde*, Bayreuth, 2: 1-88.

Oppel A., 1862 – Über jurassische Crustaceen. *Palaeontologische Mittheilungen aus dem Museum des königlich Bayerischen Staates*, Stuttgart, 1: 1-120.

Polz H., 1999 – *Etallonia hoellorum* sp. nov. (Crustacea, Decapoda, Axiidae) aus dem Oberkimmeridgium der südlichen Frankenalb. *Archaeopteryx*, Eichstätt, 17: 33-39.

Polz H., 2000 – *Glyphea viohli* sp. nov. (Crustacea: Decapoda: Glypheidae) aus den Solnhofener Plattenkalken. *Archaeopteryx*, Eichstätt, 18: 17-25.

Röper M., Rothgaenger M. & Rothgaenger K., 1996 – Die Plattenkalke von Brunn, Landkreis Regensburg. *Eichendorf (Eichendorf-Verlag)*.

Schweigert G., 1998 – Die Spurenfauna des Nusplinger Plattenkalks (Oberjura, Schwäbische Alb). *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 262: 1-47.

Schweigert G., 2001a – Dimorphismus bei Krebsen der Gattung *Cycleryon* (Decapoda, Eryonidae) aus dem Oberjura Süddeutschlands. *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 305: 1-21.

Schweigert G., 2001b – Eine neue Art der Gattung *Antrimpos* Münster (Crustacea, Decapoda, Penaeidae) aus dem Oberjura Süddeutschlands. *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 307: 1-33.

Schweigert G., 2001c – The late Jurassic decapod species *Aeger tipularius* (Schlotheim, 1822) (Crustacea: Decapoda: Aegeridae). *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 309: 1-10.

Schweigert G., 2002 – Zwei neue Garnelen (Decapoda: Dendrobranchiata, Eukyphida) aus oberjurassischen Plattenkalken Süddeutschlands. *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 323: 1-11.

Schweigert G., 2003 – *Megachela frickhingeri* n. g. n. sp. (Crustacea: Decapoda: Thalassinidea: Axiidae) aus dem Solnhofener Plattenkalk (Ober-Jura, Bayern). *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 333: 1-12.

Schweigert G., in press – Ammonite biostratigraphy as a tool for dating Upper Jurassic lithographic limestones from South Germany – first results and open questions. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, Stuttgart.

Schweigert G. & Dietl G., 2005 – Miscellanea aus dem Nusplinger Plattenkalk (Ober-Kimmeridgium, Schwäbische Alb) 6. Die Spurengattung *Telsonichnus*. *Jahresberichte und Mitteilungen des Oberrheinischen geologischen Vereins, neue Folge*, Stuttgart, 87: 431-438.

Schweigert G., Dietl G. & Röper M., 2000 – Die Panzerkrebse der Familie Erymidae van Straelen (Crustacea, Decapoda) aus dem Nusplinger Plattenkalk (Ober-Kimmeridgium, Schwäbische Alb) im Vergleich mit fränkischen Vorkommen. *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 285: 1-25.

Schweigert G. & Garassino A., 2003 – New studies of decapod crustaceans from the Upper Jurassic lithographic limestones of southern Germany. *Contributions to Zoology*, The Hague, 72: 173-179.

Schweigert G. & Garassino A., 2004 – New genera and species of shrimps (Crustacea: Decapoda: Dendrobranchiata, Caridea) from the Upper Jurassic lithographic limestones of S Germany. *Stuttgarter Beiträge zur Naturkunde*, Serie B, Stuttgart, 350: 1-33.

Schweigert G. & Garassino A., 2005a – The lobster genus *Squamosoglyphea* Beurlen, 1930 (Crustacea: Decapoda: Glypheidae) in the Upper Jurassic lithographic limestones of southern Germany. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, Stuttgart, 2005: 269-288.

Schweigert G. & Garassino A., 2005b – First record of the shrimp genus *Carpopenaeus* Glaessner, 1945 (Crustacea: Decapoda: Carpopenaeidae) from the Jurassic. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, Stuttgart, 2005: 490-502.

Schweigert G. & Garassino A., 2006 – News on *Pleopteryx kuempeli* Schweigert & Garassino, an enigmatic shrimp (Crustacea: Decapoda: Caridea: Pleopteryxoidea superfam. nov.) from the Upper Jurassic of S Germany. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, Stuttgart, 2006: 449-461.

Vallon L. H. & Röper M., 2006 – *Tripartichnus* (n. igen.) – A new trace fossil from the Buntsandstein (Lower Triassic) and from the Solnhofen Lithographic Limestone (Upper Jurassic). *Paläontologische Zeitschrift*, Stuttgart, 80: 156-166.

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Volume XXXV – Fascicolo II

Carrie E. Schweitzer, Rodney M. Feldmann, Aubrey M. Shirk &
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Differential diversity in Jurassic sponge-algal and coralline communities, Romania

Detailed collection and evaluation of decapod faunas from various reef settings in eastern and central Romania demonstrate diversity differences and differential habitat preferences early in the history of the Anomura and Brachyura.

Abundant and diverse decapod faunas have been reported from three sets of coral-dominated reef localities in the vicinity of the southeastern Carpathian Mountains near the towns of Sinaia and Braşov, Romania. The reef localities near Sinaia are generally grouped together with that near Moroeni in faunal counts (Patrulius, 1959, 1966). The Sinaia localities consist of olistolith blocks situated in the mountains above the town of Sinaia; many are no longer accessible due to recent housing and infrastructure development in the area. The Moroeni locality was a large olistolith block near a tuberculosis sanitorium in the village of Moroeni, south of Sinaia; that block is all but grown over with vegetation. Patrulius collected these areas extensively and reported as many as 38 decapod species from 20 genera from this set of localities (Patrulius, 1966). Our collecting in these localities yielded significantly fewer taxa. Unfortunately, Patrulius's systematic work on these decapods was never published, and it is difficult to compare the number of species from our work with Patrulius's list without an evaluation of his material. In addition to the decapods, our collecting also yielded corals, brachiopods, pelecypods, and echinoderms from these localities.

The decapods from the locality at Purcăreni were also preliminarily reported by Patrulius (1966) but were never formally published. He reported as many as 18 species in 12 genera from the Purcăreni olistolith, known locally as the "coral rock" and located east of Braşov. Collecting of that olistolith during the field seasons of 2004 and 2005 yielded 6 additional species in 5 additional genera (Shirk, 2006). Shirk (2006) also reported several species each of brachiopods, corals, pelecypods, and gastropods as well as ammonoids, crinoids, sponges, and trace fossils from this locality.

Muțiu & Bădăluță (1971) reported a small decapod fauna from a reef locality southeast of the Carpathians in eastern Romania that included 7 species in 6 genera. They also reported corals, sponges, brachiopods, and pelecypods associated with the decapods. Thus, it is clear that the coral reef faunas, both in terms of decapods and other invertebrates, were generally diverse and robust.

Analysis of the decapods collected from sponge-algal megafacies in southeastern Romania (Central Dobrogea) demonstrates that such of differing geometries appear to have hosted slightly different, low-diversity decapod faunas that lived within the magafacies structures. Layered sponge biostromes at the Gura Dobrogei, Romania, locality include four species of brachyurans and several indeterminate claw fragments. The identifiable genera, representing the Goniodromitinae Beurlen, 1932, and Prosopinae von Meyer, 1860, of the Prosopidae von Meyer, 1860, include *Goniodromites* Reuss, 1859, and *Cycloprosopon* Lőrenthey *in* Lőrenthey & Beurlen, 1929, of the Goniodromitinae, and a new taxon within the Prosopinae. Giant, cylindrical, sponge bioherms in the Cheia Valley, not far from the Gura Dobrogei locality, yielded not only species of *Goniodromites* and *Cycloprosopon* as well as claw fragments, similar to the Gura Dobrogei locality, but also a species of *Pithonoton* von Meyer, 1842 (Feldmann *et al.*, 2006). In addition, one of the fragmental specimens appears to have strong affinities with *Pithonoton insigne* von Meyer, 1857, a species known only from sponge megafacies or laminated limestones (G. Schweigert, personal commun.; Collins & Wierzbowski, 1985). The cylindrical bioherm structures also yielded sponges, annelid worms, brachiopods, and belemnites (Feldmann *et al.*, 2006). The prosopid genus collected from the Gura Dobrogei locality was not present in the cylindrical reefs in the Cheia Valley. Both sets of localities received about equal collecting effort, based upon the size of outcrop, and the same collecting team worked at both sets of localities, so it seems unlikely that there was a collecting bias between the sites. The presence of claw and appendage fragments at both localities suggests that the animals were living within the sponge reefs. Had the decapod fragments been carried into the area by currents, the tiny appendage and claw fragments, and even the tiny carapaces, would probably have been destroyed. In addition, the decapods collected in association with the cylindrical sponge bioherms showed some level of habit partitioning, with some showing preferences for the bioherm itself, the inter-bioherm talus, and the central core area of the bioherm (Feldmann *et al.*, 2006). This specialization for different parts of the bioherm as well as slightly different faunas in bioherms of differing geometries suggests that habitat partitioning was off to an early and earnest start within the Brachyura.

Of the decapods collected from the coral reef localities, most were not collected from the sponge localities. Only three genera, *Cycloprosopon*, *Goniodromites*, and *Pithonoton*, were collected from both sponge and coral reef localities. The new prosopid genus and the possible specimen of *Pithonoton insigne* are the only decapod taxa collected only from sponge-algal habitats. Thus, it appears that many more genera were specialized for coral reef habitats than for sponge habitats, perhaps due to the shallower, better oxygenated, better illuminated environment there. It is also probable that, due to the nature of the wide variety

of morphology of corals, there are more niches and physical spaces for tiny crabs to hide, reproduce, and molt than would be available in sponge-algal habitats, composed of cylindrical, conical, or layered sponges.

The three genera *Cycloprosopon*, *Pithonoton*, and *Goniodromites*, appear to have been generalists, able to survive in coral and sponge-algal habitats. The eurytopic adaptations of these three genera may account for their repeated presence in species and generic lists of Jurassic crabs; certainly, various species of *Goniodromites* as well as *P. marginatum* von Meyer, 1842, are some of the most commonly encountered taxa in Jurassic decapod studies. More often than not, these identifications seem to be consistent with the historic conception of these taxa, based upon our survey of material in several museums over the past two summers. If these taxa were indeed generalists, they would have been able to survive in many environments which may in turn have allowed their survival for a long duration of geologic time, which may also contribute to their commonality in Jurassic deposits across Europe. Detailed examination of specimens of these taxa is ongoing in an attempt to determine which morphological features specifically may have contributed to their broad adaptability.

When evaluating the Romanian reef decapods at the family and subfamily level, it is notable that several groups are absent from the sponge-algal habitats. Family level classification for the purposes of this work largely follows Patrulius (1966), whereas subfamily level classification follows Glaessner (1969). We do not consider *Laeviprosopon* Glaessner, 1933, to be a homolid as did Patrulius (1966), because it clearly lacks *lineae homolicae*. Notably absent from the sponge-algal habitats is the Galatheidae Samouelle, 1819, which is well-represented in all three of the coral reef localities surveyed here. Also almost completely lacking from the sponge-algal habitats, with the exception of one genus and species, is the Prosopinae. The Goniodromitinae is well-represented in both coral reef and sponge-algal habitats, suggesting that as for the two included genera, *Goniodromites* and *Pithonoton*, the subfamily itself may have been broadly adapted and eurytopic. The same may also have been true for the early Dynomenidae Ortmann, 1892, well-represented in coral reef habitats and represented by one genus and species within sponge-algal habitats. Investigation of the evolutionary patterns within these families and their relationships with reefs of varying types is ongoing.

Table 1 - Decapoda reported from the Sinaia and Moroeni localities. Data from Patrulius (1959, 1966).

Family Axiidae Huxley, 1879	
Palaeoaxius Patrulius, 1959	1 species
Family Galatheidae Samouelle, 1819	
Gastrosacus von Meyer, 1851	3 species
Palaeomunida Lőrenthey, 1902	4 species
Paragalathea Patrulius, 1959	2 species
Munitheites Lőrenthey *in* Lőrenthey & Beurlen, 1929	1 species
Family Prosopidae von Meyer, 1860	
Subfamily Prosopinae von Meyer, 1860	
Prosopon von Meyer, 1835	2 species
Glaessneropsis Patrulius, 1959	2 species
Laeviprosopon Glaessner, 1933	1 species
Lecythocaris von Meyer, 1860	1 species
Longodromites Patrulius, 1959	3 species
Nodoprosopon Beurlen, 1928	2 species
Subfamily Goniodromitinae Beurlen, 1932 (= Pithonotinae Glaessner, 1933)	
Goniodromites Reuss, 1859	1, perhaps 3 species
Eodromites Patrulius, 1959	3 species
Coelopus Étallon, 1861	1 species
Pithonoton von Meyer, 1842	2 species
"Goniodromites" etalloni Gemmellaro, 1870	
Family Homolidae de Haan, 1839	
Tithonohomola Glaessner, 1933	1 species
Family Dynomenidae Ortmann, 1892	
Cyclothyreus Remeš, 1895	1 species
Cyphonotus Bell, 1863	2 species
Family Uncertain	
Oxythyreus Reuss, 1859	1 species
Decapod total: 20 genera	38 species maximum

Table 2 - Decapoda reported from the Ghergheasa locality. Data from Mutiu & Bădăluță (1971).

Family Galatheidae Samoulle, 1819	
Gastrosacus von Meyer, 1851	1 species
Palaeomunida Lőrenthey, 1902	1 species
Paragalathea Patrulius, 1959	1 species
Family Prosopidae von Meyer, 1860	
Subfamily Prosopinae von Meyer, 1860	
Longodromites Patrulius, 1959	2 species
Subfamily Goniodromitinae Beurlen, 1932	
Goniodromites Reuss, 1859	1 species
Pithonoton von Meyer, 1842	1 species
Decapod total: 6 genera	7 species
Sponges	
Corals	
Brachiopods	
Clams	

Table 3 - Decapoda reported from the Purcăreni locality. Data from Patrulius (1966) and Shirk (2006).

Family Galatheidae Samouelle, 1819	
Eomunidopsis Via Boada, 1981	2 species
Gastrosacus von Meyer, 1851	1 species
Palaeomunida Lőrenthey, 1902	4 species
Paragalathea Patrulius, 1959	3 species
Family Prosopidae von Meyer, 1860	
Subfamily Prosopinae von Meyer, 1860	
Longodromites Patrulius, 1959	1 species
Subfamily Goniodromitinae Beurlen, 1932	
Goniodromites Reuss, 1859	2 species
Coelopus Étallon, 1861	1 species
Cycloprosopon Lőrenthey *in* Lőrenthey & Beurlen, 1929	1 species
Eodromites Patrulius, 1959	1 species
Pithonoton von Meyer, 1842	2 species
"Goniodromites" etalloni Gemmellaro, 1870	
Family Dynomenidae Ortmann, 1892	
Dynomene Latreille *in* Desmarest, 1825	1 species
Cyclothyreus Remeš, 1895	2 species
Cyphonotus Bell, 1863	1 species
Family Uncertain	
Oxythyreus Reuss, 1859	1 species
Decapod total: 16 genera	24 species
Brachiopoda	
Cnidaria	
Pelecypoda	
Gastropoda	
Ammonoidea	
Crinoidea	
Porifera	
Trace fossils	

References

Bell T., 1863 – A monograph of the fossil malacostracous Crustacea of Great Britain, Pt. II, Crustacea of the Gault and Greensand. *Palaeontographical Society Monograph*, London.

Beurlen K., 1928 – Die fossilen Dromiaceen und ihre Stammesgeschichte. *Paläontologische Zeitschrift*, Berlin, 10: 144-183.

Beurlen K., 1932 – Brachyurenreste aus dem Lias von Bornholm mit Beiträgen zur Phylogenie und Systematik der Brachyuren Dekapoden. *Paläontologische Zeitschrift*, Berlin, 14: 52-66.

Collins J. S. H. & Wierzbowski A., 1985 – Crabs from the Oxfordian sponge megafacies of Poland. *Acta Geologica Polonica*, Warzawa, 35 (1-2): 73-88.

Étallon A., 1861 – Notes sur les Crustacés Jurassiques du bassin du Jura. *Mémoires de la Societé de l'Agriculture, des Sciences et Lettres de la Haute Saône*, Vesoul, 9: 129-171.

Feldmann R. M., Lazăr I. & Schweitzer C. E., 2006 – New crabs (Decapoda: Brachyura: Prosopidae) from Jurassic (Oxfordian) sponge bioherms of Dobrogea, Romania. *Bulletin of the Mizunami Fossil Museum*, Mizunami, 33: 1-20.

Gemmellaro G. G., 1870 – Studi paleontologici sulla fauna del calzare a *Terebratula janitor* del Nord di Sicilia. Parte I, *Stabilimento Tipografico Lao*, Palermo.

Glaessner M. F., 1933 – Die Krabben der Juraformation. *Zentralblatt für Mineralogie, Geologie und Palaontologie*, Stuttgart, Abtheilung B: 178-191.

Glaessner M. F., 1969 – Decapoda, p. R400-R533, R626-628. In: Treatise on Invertebrate Paleontology. R. C. Moore (ed.). Pt. R4 (2). *Geological Society of America and University of Kansas Press*, Lawrence.

Haan W. de, 1833-1850 – Crustacea. In: *Fauna Japonica sive Description Animalium, quae in Itinere per Japoniam, Jussu et Auspiciis Superiorum, qui Summum in India Batava Imperium Tenent, Suscepto, Annis 1823-1830 Collegit, Notis, Observationibus et Adumbrationibus Illustravit*. P. F. von Siebold & J. Müller (eds). Lugduni-Batavorum (=Leiden).

Huxley T. H., 1879 (1878) – On the classification and the distribution of the crayfishes. *Proceedings of the Scientific Meetings of the Zoological Society of London*, London, 1878: 752-788.

Latreille P. A., 1825 – Histoire Naturelle Entomologie ou Histoire naturelle des Crustacés, des Arachnides et des Insectes. In: Encyclopédie Méthodique. A. G. Desmarest (ed.). *Roret*, Paris, 10: 1-344.

Lőrenthey E., 1902 – Neue Beiträge zur tertiären Decapodenfauna Ungarns. *Mathematisch-Naturwissenschaftliche Berichte aus Ungarn*, Budapest, 18: 98-120.

Lörenthey E. & Beurlen K., 1929 – Die fossilen Decapoden der Länder der Ungarischen Krone. *Geologica Hungarica, Serie Paleontologica*, Budapest, 7 (3): 1-420.

Meyer H. von, 1835 – Briefliche Mitteilungen. *Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie*, Stuttgart.

Meyer H. von, 1842 – Über die in dem dichten Jurakalk von Aalen in Würtemburg vorkommenden Spezies des Crustaceengenus *Prosopon*. *Beiträge zur Petrefaktenkunde*, Bayreuth, Heft 5: 70-75.

Meyer H. von, 1851 – Briefliche Mitteilgungen. *Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie*, Stuttgart.

Meyer H. von, 1857 – Briefliche Mitteilungen. *Jahrbuch für Mineralogie, Geologie, und Paläontologie*, Stuttgart.

Meyer H. von, 1860 – Die Prosoponiden oder die Familie der Maskenkrebse. *Palaeontographica*, Stuttgart, 7: 183-222.

Mutiu R. & Bădăluță A., 1971 – La présence des décapodes anomures et dromiacés dans les calcaires tithoniques de Plate-Forme Moësienne. *Annales Instituti Geologici Publici Hungarici*, Budapest, 54 (2): 245-525.

Ortmann A., 1892 – Die Abtheilungen Hippidea, Dromiidea, und Oxystomata: Die Decapoden-Krebse des Strassburger Museums, mit besonderer Berücksichtigung der von Herrn Dr. Döderlein bei Japan und bei den Liu-Kiu-Inseln gesammelten und z.Z. im Strassburger Museum aufbewahrten Formen. V. Theil. *Zoologische Jahrbücher, Abtheilung für Systematik, Geographie, und Biologie der Thiere*, 6: 532-588.

Patrulius D., 1959 – Contributions à la systématique des décapodes néojurassiques. *Revue de Géologie et Géographie*, Bucharest, 3 (2): 249-257.

Patrulius D., 1966 – Les Décapodes du Tithonique inférieur de Wozniki (Carpates Polonaises Occidentales). *Annales de la Société Géologique de Pologne*, Kraków, 36 (4): 495-517.

Remeš M., 1895 – Beiträge zur Kenntnis der Crustaceen der Stramberger Schichten. *Bulletin International de l'Académie des Sciences de Bohème,* Prague, 2: 200-204.

Reuss A. E., 1859 – Zur Kenntnis fossiler Krabben. *Akademie der Wissenschaften Wien*, Vienna, Denkschrift 17: 1-90.

Samouelle G., 1819 – The Entomologist's Useful Compendium, or an Introduction to the British Insects, etc. *T. Boys*, London.

Shirk A. M., 2006 – A novel assemblage of decapod Crustacea, from a Tithonian coral reef olistolith, Purcăreni, Romania: systematical arrangement and biogeographical perspective. Unpublished Master's Thesis, Kent State University, Kent, Ohio, USA.

Via Boada L., 1981 – Les Crustacés Décapodes du Cenomanien de Navarra (Éspagne): Premiers résultats de l'étude des Galatheidae. *Géobios*, Lyon, 14 (2): 247-251.

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Volume XXXV – Fascicolo II

Giorgio Teruzzi & Alessandro Garassino

Coleia Broderip, 1835 (Crustacea, Decapoda, Coleiidae) from the Mesozoic of Italy: an update

The discovery of *Coleia* Broderip, 1835, from the Lower Jurassic (Sinemurian) of Osteno (Lugano Lake, N Italy) was reported for the first time by Pinna (1968, 1969) who recorded nine specimens, referring them to *C. mediterranea* Pinna, 1968, and *C. viallii* Pinna, 1968. The first, well known by some very well preserved specimens, shows the following morphological characters: subrectangular carapace with deep cervical and post-cervical incisions; ocular incision with evident supra-antennal spine; cervical groove deeper than branchiocardiac groove; strong postcervical median carina and two strong branchial carinae; pereiopod I longer than the body length; short triangular carpus; movable and fixed fingers with distal extremity slightly curved; subtriangular telson with median spine and two lateral spines at the distal extremity; petaloid uropodal exopod with rounded diaeresis. The second, known by some complete specimens, shows the following morphological characters: subrectangular carapace; wide ocular incisions with supra-antennal spines and separated by a shallow intraocular incision; narrow cervical incisions and wide postcervical incisions; deep cervical groove V-shaped; slender postrostral and postorbital carinae; postcervical median carina stronger than two branchial carinae; abdomen longer than carapace; abdominal somites I-V with a strong and median tubercle; chela of pereiopod I with movable finger bent at the distal extremity and as long as the fixed finger; pereiopods II-IV shorter than pereiopod I and with little chelae; triangular telson with two tuberculate lateral carinae; petaloid uropodal exopod with sinuous diaeresis.

Field researches in Osteno outcrop during the eighties and nineties of the last century yielded many specimens studied by Teruzzi (1990) who recorded 12 complete and incomplete specimens, referring them to C. *pinnai* Teruzzi, 1990, and *C. popeyei* Teruzzi, 1990.

The first shows the following morphological characters: subrectangular carapace; almost straight frontal margin with two little supraorbital spines; ocular incisions with supra-antennal spine; cervical incisions deeper than postcervical incisions; cervical and branchiocardiac grooves V-shaped; postcervical median carina stronger than two branchial carinae; very elongate and thin pereiopod I; chela of pereiopod I with movable finger at the distal extremity curved and longer than fixed finger; subtriangular telson with distal extremity rounded and with lateral carinae; and oval uropodal exopod with rounded diaeresis. The second species shows the following morphological characters: subrounded carapace; almost straight frontal margin with a wide intraocular incision; cervical groove V-shaped; slender median postcervical carina; two slender branchial carinae; pereiopod I with strong and stout propodus; chela of pereiopod I with movable and fixed fingers at the distal extremity slightly curved and similar in length; subtriangular telson with two lateral carinae; and uropodal exopod with rounded diaeresis.

Recently, Garassino & Gironi (2006) described 47 very well preserved specimens from Monte Verzegnis (Udine) from the Upper Triassic (Rhaetian), referring them to *Coleia boboi* Garassino & Gironi, 2006, having the following morphological characters: subovoid carapace with two strong and elongate supraorbital spines; two thin postorbital carinae; thin median postcervical carina; two thin branchial carinae; deep cervical groove; deep cervical and postcervical incisions dividing the margin into three parts; chela of pereiopod I with movable and fixed fingers gently bent at the distal extremity and similar in length; subtriangular telson with two strong tuberculate lateral carinae and spiny lateral margins; and rounded uropodal exopod with rounded diaeresis.

Today, *Coleia* Broderip, 1835, known from the Upper Triassic (Carnian) to the Upper Jurassic (Tithonian) of Europe (Germany, Great Britain, France, Russia and Italy), Japan, and Madagascar, includes 22 species: 2 species from the Upper Triassic: *C. uzume* Karasawa, Takahashi, Doi & Ishida, 2003, and *C. boboi* Garassino, & Gironi 2006; 18 species from the Lower Jurassic: *C. antiqua* Broderip, 1835; *C. barrovensis* (McCoy, 1849); *C. escheri* (Oppel, 1862); *C. edwardsi* (Moriére, 1864); *C. wilmcotensis* (Woodward, 1866); *C. moorei* (Woodward, 1866); *C. brodiei* (Woodward, 1866); *C. crassichelis* (Woodward, 1866); *C. morierei* (Renault, 1889); *C. tenuichelis* Woods, 1925; *C. bredonensis* Woods, 1925; *C. sinuata* Beurlen, 1928; *C. sibirica* Chernyshev, 1930; *C. theodorii* Kuhn, 1952; *C. viallii* Pinna, 1968; *C. mediterranea* Pinna, 1968; *C. pinnai* Teruzzi, 1990; *C. popeyei* Teruzzi, 1990; and 2 species from Upper Jurassic: *C. longipes* (Fraas, 1855), and *C. incerta* Secretan, 1964.

References

Garassino A. & Gironi B., 2006 – *Coleia boboi* n. sp. (Crustacea, Decapoda, Eryonoidea) from the Late Triassic (Rhaetian) of Monte Verzegnis (Udine, NE Italy). *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 147 (1): 93-102.

Pinna G., 1968 – Gli Erionidei della nuova fauna sinemuriana a crostacei decapodi di Osteno in Lombardia. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 107: 93-134.

Pinna G., 1969 – Due nuovi esemplari di *Coleia viallii* Pinna, del Sinemuriano inferiore di Osteno in Lombardia (Crustacea, Decapoda). *Annali del Museo di Storia Naturale di Genova*, Genova, 77: 626-632.

Teruzzi G., 1990 – The genus *Coleia* Broderip, 1835 (Crustacea, Decapoda) in the Sinemurian of Osteno in Lombardy. *Atti della Società italiana di Scienze naturali e del Museo civico di Storia naturale di Milano*, Milano, 131 (4): 85-104.

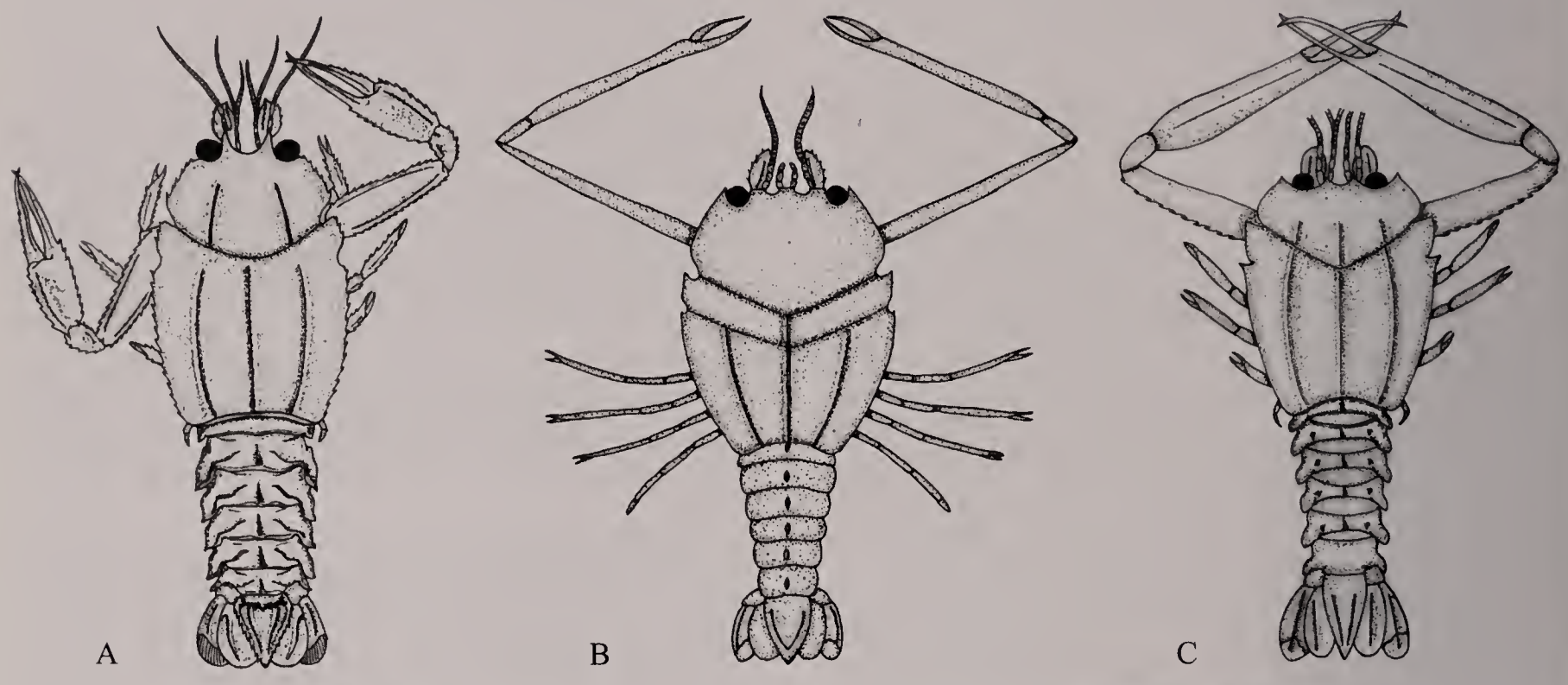

Fig. 1 – A) *C. boboi* Garassino & Giorni, 2006. B) *C. mediterranea* Pinna, 1968. C) *C. viallii* Pinna, 1968. D) *C. pinnai* Teruzzi, 1990. E) *C. popeyei* Teruzzi, 1990. (Drawings not in scale).

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Volume XXXV – Fascicolo II

Francisco J. Vega, Fernando Álvarez & Gerardo Carbot-Chanona

Albian penaeoidea (Decapoda, Dendrobranchiata) from Chiapas, southern Mexico

A new fossiliferous plattenkalk facies locality known as El Chango has yielded numerous plant remains, fishes, and crustaceans. El Chango is located approximately 30 km southwest of Tuxtla Gutiérrez, Chiapas (Fig. 1). Laminar dolomites of variable thickness (2 to 60 cm) crop out in valleys of a karstic landscape. These deposits correspond to the base of the Sierra Madre Formation, defined as a 2,590 m sequence of Aptian to Santonian dolomites and limestones (Fig. 2), deposited mainly on shallow marine facies (Steele & Waite, 1986). Recently, another age equivalent locality has been reported to contain plant remains, insects, numerous and diverse crustaceans, as well as fishes (Vega *et al.*, 2006).

Fossils from El Chango include plant remains that resemble *Brachyphyllum*? sp., as well as other diverse leaves (Figs. 3A-3D). Fishes of different species and sizes are also found (Figs. 3E-3F), including macrosemiid fishes and other groups with affinities with Asian and south American forms (Ovalles-Damián *et al.*, 2006). Crustacean remains are rather scarce, and include possible dorippid crabs (Fig. 3G) and shrimps (Figs. 3H-3L), whose preservation is usually very poor, but the occurrence is significant because they represent the first fossil penaeoids described from Mexico.

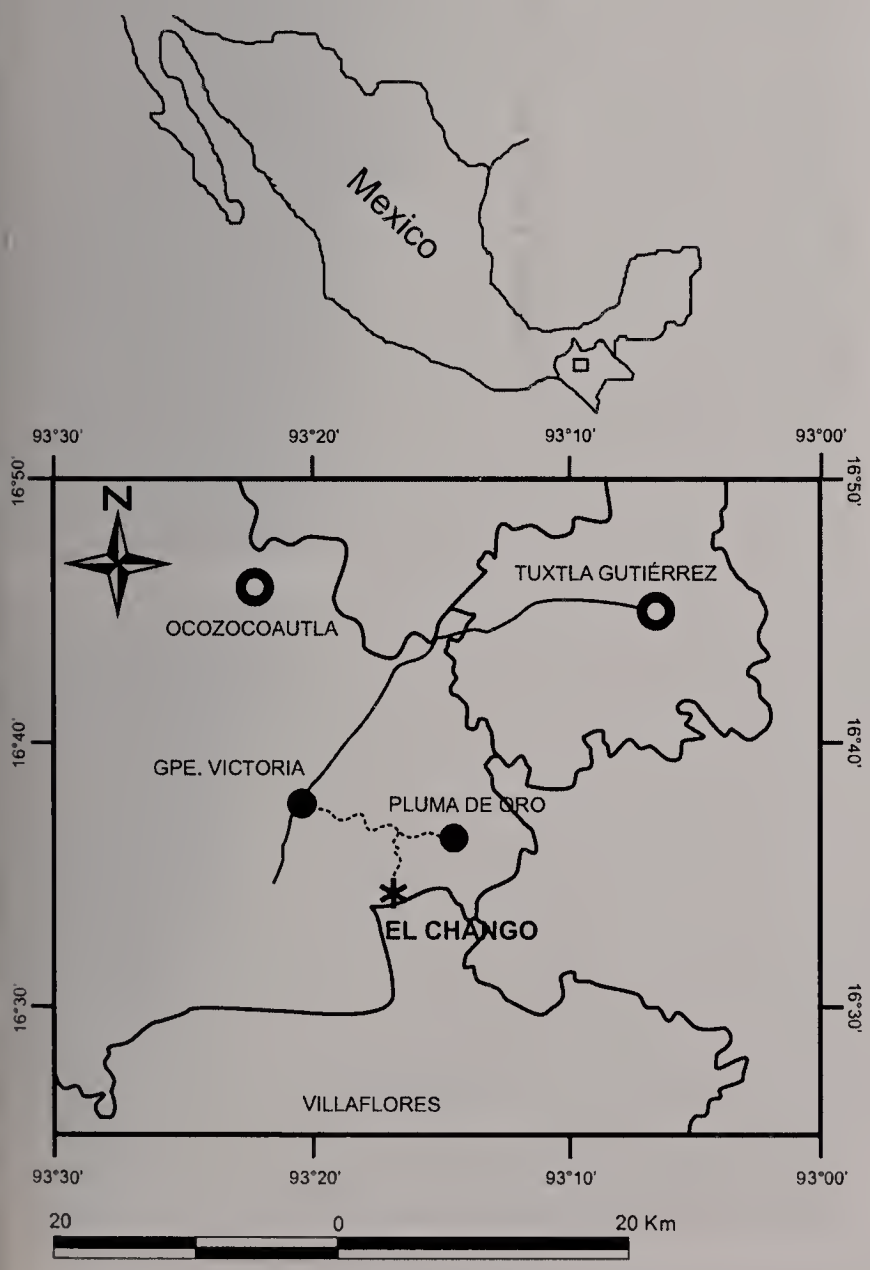


Fig. 1 - Location map of El Chango, Ocozocozutla County, Chiapas, southern Mexico.

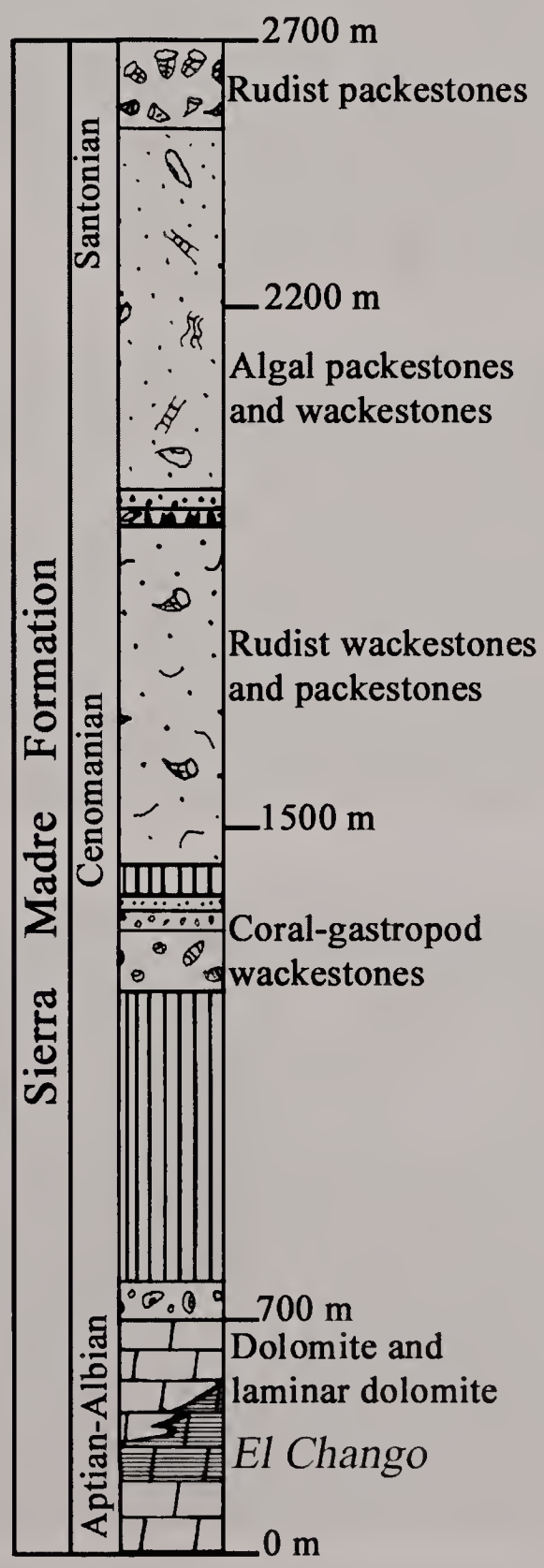


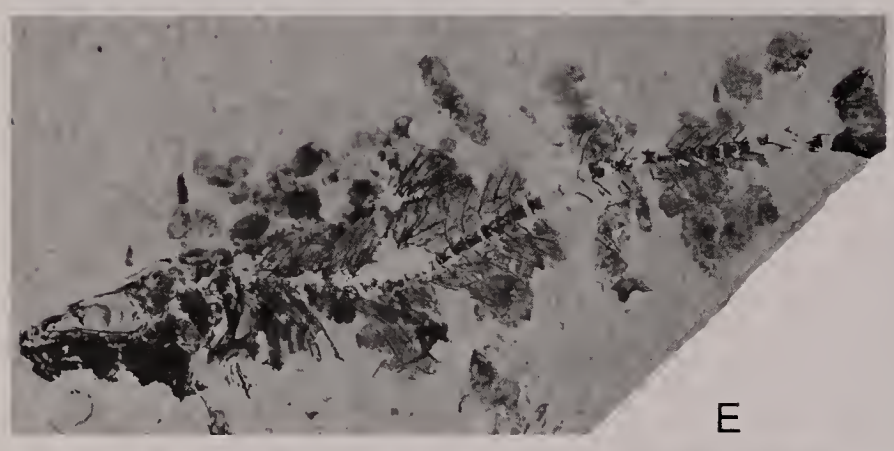
Fig. 2 - Stratigraphic section of the Sierra Madre Formation, showing relative position of deposits that crop out at El Chango.

A

B

C

D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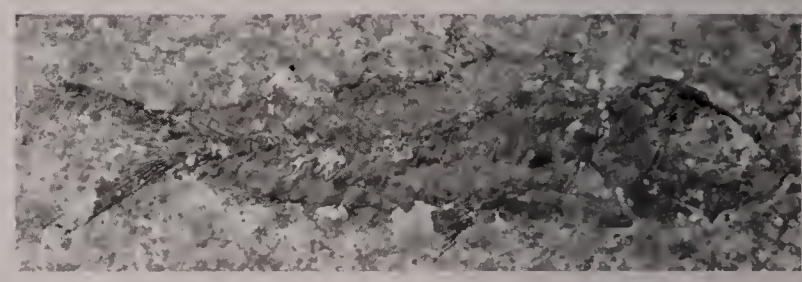
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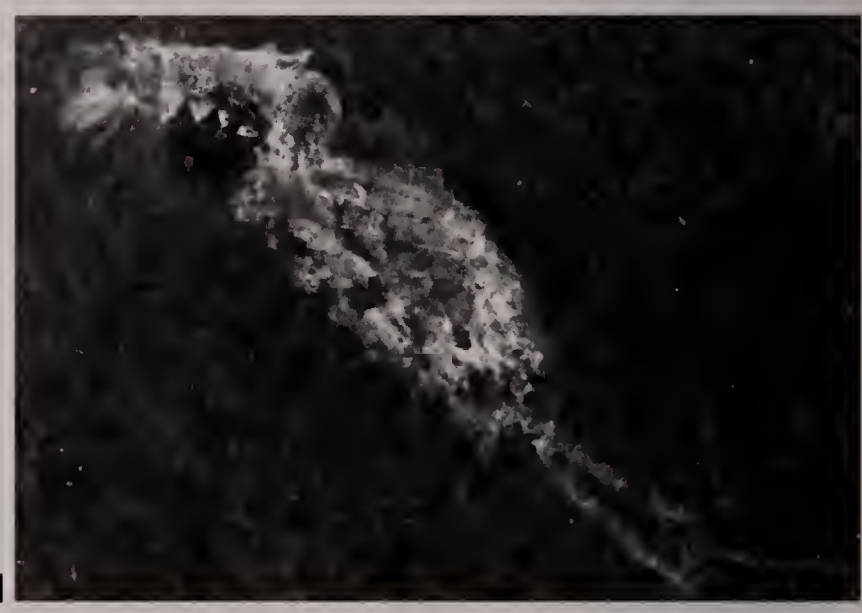
H

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Fig. 3 – A-B) *Brachyphyllum*? sp., X 2.0. C-D) Unidentified plant remains, X 0.5. E-F) Unidentified fishes. E) X 0.3; F) X 5.0. G) Dorippid? crab, hypotype IHNFG-2928, X 4.0. H-L) Unidentified crustaceans. H) Hypotype IHNFG-2929, X 5.0. I) Lost specimen, X 5.0 (scale in original photograph). L) Hypotype IHNFG-2930, X 5.0.

This locality is similar in age and lithology to the one found near Profeti, Italy, from where palaeomonids and carideans have been reported (Bravi & Garassino, 2000).

Specimens are deposited in the paleontological collection of the Museo de Paleontología Eliseo Palacios Aguilera, Instituto de Historia Natural y Ecología, Tuxtla Gutiérrez, Chiapas, under acronym IHNFG.

Systematic paleontology

Superfamily Penaeoidea Rafinesque, 1815
Family Penaeidae? Rafinesque, 1815

Description. Rostrum short, probably reaching distal portion of first antennular article. Dorsal surface of rostrum with seven regularly spaced teeth, decreasing in size anteriorly; posterior-most teeth above posterior margin of orbit. Tip acute, simple. Ventral surface of rostrum smooth, devoid of teeth. Carapace smooth, globose; dorsal surface devoid of teeth beyond rostral ones. Antennal angle with well defined spiniform projection. Pterygostomian angle undefined. Ventral margin broadly rounded. Posterior margin simple, straight. Abdomen smooth without obvious notches or grooves. First abdominal somite shortest, 0.6 times the length of second somite; posterolateral margin of pleuron overlapping second somite, ventral margin rounded. Second somite approximately rectangular, posterior margin of pleuron slightly concave. Third somite longer than first two, ventral margin rounded; interlocking midlateral hinge present on posterolateral margin of pleuron. Fourth somite of about same length as third one, similar in shape; interlocking midlateral hinge present on posterolateral margin of pleuron. Fifth somite shorter than fourth, pleuron approximately rectangular; interlocking midlateral hinge present on posterolateral margin of pleuron. Sixth somite the longest; dorsal, ventral, and posterior margins of pleuron straight. Telson shorter than uropods. Eyes well developed, cornea spherical. Antennule with peduncle shorter than scaphocerite, antennular flagellum long, about 4 times as long as total length of organism. Scaphocerite 1.4 times as long as antennular peduncle. Pereopods slender, ischia and carpi of all five pairs very similar in width and length.

Material. One specimen, hypotype IHNFG-2931 (Fig. 4).

Measurements. Carapace length = 41.7 mm, width = 11.1 mm.

Remarks. The present specimen is placed in the Penaeoidea based on its general shape, a pleuron of the first abdominal somite that overlaps that of the second one, and five pereiopods of apparently the same thickness. Unlike modern species of penaeidae, the rostral teeth in the Chiapas shrimp are all restricted to the anterior-most portion of the rostrum anterior to the posterior margin of the orbit. In modern penaeidae, there is always an epigastric tooth, posterior to the orbit, or a series of teeth that reach the posterior half of the carapace along a mid-dorsal carina (Pérez-Farfante & Kensley, 1997). We compared our material with Jurassic and Cenomanian penaeoideans from Solnhofen and Lebanon (Schweigert, 2001; Schweigert & Garassino, 2004; Garassino, 1994). Those penaeoideans are different from the Mexican specimen in having rostra of different shape and length. The Chiapas shrimp is similar in body proportions to the extant *Farfantepenaeus* and *Litopenaeus*, some of whose species inhabit Mexican waters. The first abdominal somite is short, the rostrum lacks ventral teeth, unlike modern penaeidae. Future field work may produce more and best preserved specimens, in order to define if this form represents a new genus.

Fig. 4 – Penaeidae? Hypotype IHNFG-2931, X 2.5. Photo and line drawing.

References

Bravi S. & Garassino A., 1998 – Plattenkalk of the Lower Cretaceous (Albian) of Petina, in the Alburni Mounts (Campania, S Italy) and its decapod crustacean assemblage. *Atti della Societá italiana di Scienze naturali e del Museo civico di Storia naturale in Milano*, 138: 89-118.

Bravi S. & Garassino A., 2000 – The Profeti platy dolomite and its decapod crustacean assemblage. *Studi e Ricerche, Associazione Amici del Museo - Museo Cívico "G. Zannato",* Montecchio Maggiore (Vicenza), 2000: 11-13.

Garassino A., 1994 – The macruran decapod crustaceans of the Upper Cretaceous of Lebanon. *Paleontologia Lombarda,* Nuova serie, Milano, III: 1-27.

Ovalles-Damián E., Alvarado-Ortega J. & Blaco-Piñón A., 2006 – Los peces fósiles del Cretácico Inferior de Chiapas. In: X Congreso Nacional de Paleontología, México City, Memorias.

Pérez-Farfante I. & Kensley B., 1997 – Penaeoid and Segerstoid Shrimps and Prawns of the World. Keys and Diagnoses for the Families and Genera. *Mémoires du Múseum national d'Histoire naturelle*, 175: 1-233.

Rafinesque C. S., 1815 – Analyse de la Nature, ou Tableau de l'Univers et des corps Organises. Palermo.

Schweigert G., 2001 – Eine neue Art der Gattung *Antrimpos* Münster (Crustacea: Decapoda: Penaeidae) aus dem Oberjura Süddeutschlands. *Stuttgarter Beitrage zur Naturkunde, Series B*, Stuttgart, 307: 1-33.

Schweigert G. & Garassino A., 2004 – New genera and species of shrimps (Crustacea: Decapoda: Dendrobranchiata: Caridea) from the Upper Jurassic lithostratigraphic limestones of S Germany. *Stuttgarter Beitrage für Naturkunde,* Serie B, Stuttgart, 350: 1-33.

Steele D. R. & Waite L. E., 1986 – Contributions to the stratigraphy of the Sierra Madre Limestone (Cretaceous) of Chiapas. *México, Universidad Nacional Autónoma, Instituto de Geología, Boletín*, 102: 1-175.

Vega F. J., García-Barrera P., Perrilliat M. C., Coutiño M. A. & Mariño-Pérez R., 2006 – El Espinal, a new plattenkalk locality from the Lower Cretaceous Sierra Madre Formation, Chiapas, Southeastern Mexico. *Revista Mexicana de Ciencias Geológicas*, 23 (3): 323-333.

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James R. Verhoff, Pál M. Müller, Rodney M. Feldmann &
Carrie E. Schweitzer

A novel Paleocene decapod fauna from the Kambühel Formation

The Paleocene Kambühel Formation of eastern Austria preserves a decapod fauna that existed after the K/T mass extinction. The fauna contains a diverse assemblage of brachyurans (true crabs) and anomurans (including squat lobsters). These crabs and squat lobsters were reef-dwelling organisms that were part of a community structure that was preserved in rocks formed before and after the K/T extinction (Müller, 2004). This makes the Kambühel Formation important to any attempt to understand the effect of the K/T mass extinction on decapods.

Reefs were extremely favorable places for preservation of decapod crustaceans, specifically brachyurans and anomurans (Müller, 2004). Several types of reefs have been preserved in the fossil record, with most of the crab material found in patch-reefs or coral-carpets (Müller, 2004). The Kambühel Formation itself is probably a preserved fringing reef (Müller, 2004). Despite the excellent preservational potential, little is known about the history of decapods associated with reefs. This may be due to the small size of the decapod fossils which makes them difficult to recognize, hard to collect, and of little interest to collectors (Müller, 2004). The small size, combined with the relatively fragile carapace, of brachyurans makes them difficult to preserve, unless there is a sheltered area in which the carapaces can be embedded and buried (Müller, 2004). Decapod remains can also be swept off the reef and collected in fissures and cavities (Müller, 2004). Such preservation does tend to create biases, however. Specifically, the remains are generally disarticulated, the remains are sorted by size, and more chelae than carapaces are preserved (Müller, 2004). Also, it must be noted that, due to the patchy nature (both temporally and spatially) of the decapod reef faunas, it is impossible to identify whether any change was gradual or punctuated (Müller, 2004).

To analyze decapod survival, it is important to look at other taxa that were affected by the K/T mass extinction. The Kambühel Formation has been interpreted as having been deposited in a reef environment. The effects of the K/T extinction on corals, discussed below, were dramatic, and the impact of these changes on the decapods found in the Kambühel Formation is as yet unknown. Also, a shift in plankton dominance is associated with the K/T mass extinction, which may have affected crabs and lobsters indirectly. Finally, other survivors of the K/T mass extinction show important survival strategies with which decapod survival can be compared.

Decapods as a taxon appear to have been remarkably resistant to mass extinctions. Sixty-six percent of decapod genera in Denmark and Sweden survived the K/T mass extinction despite alterations of the habitat (Collins & Jakobsen, 1994), and of the 38 families studied by Schweitzer & Feldmann (2005), 79% crossed the K/T boundary. Data on genera do show an extinction event, but this event occurred over the entire Late Cretaceous (Schweitzer & Feldmann, 2005). This is not surprising, as the Cretaceous was a time of rapid radiation and extinction for the decapods (Schweitzer & Feldmann, 2005). One study of Antarctic lobsters found that the effects of the K/T mass extinction were either subtle or nonexistent (Feldmann & Tshudy, 1989). Decapod faunas immediately following the K/T mass extinction tended to be relicts, rather than new or immigrant species (see Cope *et al.*, 2005; Feldmann & Tshudy, 1989, for examples). This may be a result of the Cretaceous radiation event. Large numbers of newly evolved taxa in the Late Cretaceous coupled with relatively few extinctions at the K/T boundary may have resulted in decapods occupying so many niches that immigrant taxa could not form stable populations in new environments.

The traits found in decapods that survived the K/T event are similar to those found in survivors in other taxa. Decapods that survived the K/T extinction extended over a broad geographic region and employed a generalist feeding strategy (Schweitzer & Feldmann, 2005). These behavioral traits are similar to those found in bivalve survivors of the K/T event. Deposit feeding bivalves, which would have had a diet similar to generalists, survived better than suspension feeding bivalves (Stilwell, 2003; Hansen *et al.*, 2004). Geographically widespread bivalves also tended to survive better than those with more restricted ranges (Stilwell, 2003). Decapods from temperate to high latitudes also tended to have better survival rates, though many taxa from subtropical environments and even from near the Chicxulub impact area in Yucutan, Mexico, survived as well (Schweitzer & Feldmann, 2005). Similarly, high-latitude bivalves had better survival rates than low-latitude bivalves, although it is not clear whether bivalves from high latitude regions survived because of latitudinal effects or because of the broad geographic ranges high latitude bivalves occupied (Stilwell, 2003).

Bivalve survivors of the K/T extinction event also had several traits that form the basis for comparison with traits of decapod survivors. Infaunal bivalves seem to have become more common after the K/T extinction, though the cause is still uncertain (see Lockwood, 2004 for further discussion). Ornamentation on bivalves was found to have no effect on survival during the K/T extinction (Kelley *et al.*, 2001). However, bivalves use different mechanisms than decapods to construct their shells. Finally, the traits that were favorable in bivalves during the recovery period were the reverse of the traits favored in the extinction-suspension feeders were favored in the recovery period, for example, while they were selected against during the extinction event itself (Stilwell, 2003).

The reefs of the Kambühel Formation were also affected by the K/T mass extinction. The K/T event had two distinct effects on such coral reefs. The extinction event selected against those corals that had forms similar to modern reef-building corals that live in association with zooxanthellae, with the end result being extinction of 30% +/-8% of coral genera (Kiessling & Baron-Szabo, 2004). However, the total volume of coral reef mass actually increased in the Paleocene, and corals became more important as reef builders after the K/T extinction (Kiessling & Baron-Szabo, 2004). The Paleocene increase in coral reef volume was concentrated in Europe, north Africa, and south America (Kiessling & Baron-Szabo, 2004). It is unknown what effect the changes in type and volume of coral had on decapods.

Plankton also played a role in the formation of substrate, and there was a high turnover in plankton at the K/T boundary. Specifically, there was a rise in biogenic silica production associated with increased dominance of diatoms and other silica-shelled plankton (Hollis, 2003). Also, smaller species of plankton began to colonize lower latitudes (Gartner, 1996). Both of these trends would have affected the substrate and food web of the decapod community in the Kambühel Formation, but the specific effects of the plankton turnover on decapods are as yet unknown.

In order to study the impact of the K/T extinction and subsequent recovery on the Kambühel decapods, the decapods will be studied within the framework of extinction/recovery studies of other organisms. It is also noted that decapods may show their own unique patterns of recovery strategies, and the Kambühel decapods provide an opportunity for such study.

References

Collins J. S. H. & Jakobosen S. L., 1994 – Synopsis of the biostratigraphic distribution of the crab genera (Crustacea, Decapoda) of the Danian (Palaeocene) of Denmark and Sweden. *Bulletin of the Mizunami Fossil Museum,* Mizunami, Japan, 21: 35-46.

Cope K. H., Utgaard J. E., Masters J. M. & Feldmann R. M., 2005 – The fauna of the Clayton Formation (Paleocene, Danian) of southern Illinois: A case of K/P survivorship and Danian recovery. *Bulletin of Mizunami Fossil Museum,* Mizunami, Japan, 32: 97-108.

Feldmann R. M. & Tshudy D. M., 1989 – Evolutionary patterns in macrurous decapod crustaceans from Cretaceous to early Cenozoic rocks of the James Ross Island region, Antarctica. *Geological Society Special Publication,* Boulder, Colorado, 47: 183-195.

Gartner S., 1996 – Calcareous nanofossils at the Cretaceous-Tertiary Boundary, 27-47. In: Macleod N. & Keller G. (eds.), Cretaceous-Tertiary Mass Extinctions; Biotic and Environmental Changes. *W. W. Norton and Company*, New York, NY.

Hansen T. A., Kelley P. H. & Haasl D. M., 2004 – Paleoecological patterns in molluscan extinctions and recoveries: comparison of the Cretaceous-Paleogene and Eocene-Oligocene extinctions in North America. *Palaeogeography, Palaeoclimatology, Palaeoecology,* Amsterdam, 214: 233-242.

Hollis C. J., 2003 – The Cretaceous/Tertiary boundary event in New Zealand: profiling mass extinction. *New Zealand Journal of Geology and Geophysics,* New Zealand, 46: 307-321.

Kelley P. H., Hansen T. A., Graham S. E. & Huntoon A. G., 2001 – Temporal patterns in the efficiency of naticid gastropod predators during the Cretaceous and Cenozoic of the United States Coastal Plain. *Palaeogeography, Palaeoclimatology, Palaeoecology,* Amsterdam, 166: 165-176.

Kiessling W. & Baron-Szabo R. C., 2004 – Extinction and recovery patterns of scleractinian corals at the Cretaceous-Tertiary boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology,* Amsterdam, 214: 195-223.

Lockwood R., 2004 – The K/T event and infaunality; morphological and ecological patterns of extinction and recovery in veneroid bivalves. *Paleobiology*, Lawrence, Kansas, 30 (4): 507-521.

Müller P. M., 2004 – History of reef-dwelling decapod crustaceans from the Palaeocene to the Miocene with comments about Mesozoic occurrences. *Földtani Közlöny,* Budapest, 134 (2): 237-255.

Schweitzer C. E. & Feldmann R. M., 2005 – Decapod crustaceans, the K/P event, and Palaeocene recovery, 17-53. In: Koenemann S. & Jenner R.A. (eds.), Crustacea and Arthropod Relationships. *Taylor & Francis Group*, New York, NY.

Stilwell J. D., 2003 – Patterns of biodiversity and faunal rebound following the K-T boundary extinction event in Austral Palaeocene molluscan faunas. *Palaeogeography, Palaeoclimatology, Palaeoecology,* Amsterdam, 195: 319-356.

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Carrie E. Schweitzer

Scaling and classification of cuticular pits in raninids

The range of morphology, size, and density of pits observed on the surface of raninid crabs is examined with the goal of creating biologically meaningful characters that can be coded for future phylogenetic analysis. In addition to morphology of the pits, the size and density of these pits is an obvious starting place in the search for characters; therefore, emphasis is placed on understanding the growth of these pits in relation to carapace size.

Cuticle samples from extant and fossil raninids have been obtained during an ongoing study of the role that cuticle microstructures may play in providing characters when constructing decapod phylogenies. Material was examined directly or cast if the material was too rare for destructive sampling. Extant cuticle from museum spirit collections was cast or a section was extracted from the branchial region of the carapace. Casts and originals were examined using the SEM or were whitened with ammonium chloride and photographed with a light microscope. Sampling of the branchial region of the dorsal carapace allowed direct comparison across taxa.

Morphologically, pits on the surface of the raninids that were examined can be classified into six groups: simple closed pits, closed pits with defined sides, closed pits with small undefined nodes, perforations, pits with setae, and pits with developed nodes and setae (Fig. 1). The six groups have been consolidated into five proposed characters by combining Perforations and Pits with Setae. Subsequent work will apply these characters and others under development to a phylogenetic analysis of the Raninidae.

Twenty species in eight raninid genera have been examined to determine pit size and density. In most the raninids observed to date, the size of the pits is observed to increase, and the density of pits to decrease, as the carapace becomes larger. The clear outliers in this trend are the samples of the Cretaceous *Eumorphocorystes sculptus* Binkhorst, 1857 and *Notopocorystes stokesi* (Mantell, 1844) that show a significantly increased density of pits in relation to their carapace size.

The link between the expanding size and decreasing density of pits (or nodes) can be expected from a simple model in which a portion of cuticle starts out with a given number and size of features, the size of which expands and density decreases with each molt. This model of growth is too simple to apply blindly, and the introduction of smaller nodes between larger ones on the surface of *Ranina ranina* (Linnaeus, 1758) clearly does not follow it. Future work will examine the allometric relationship of all cuticle features with the expectation that certain features will show no growth, others will expand with growth, and some new features will be introduced during growth.

Thus, it is possible to conclude that five proposed character states can be described for coding raninid pits in phylogenetic analysis. The size of pits on the surface of raninids tends to increase with the growth of the carapace; a corresponding decrease in the density of the pits is also observed. Understanding these growth trends allows classifying structures as large or small based upon average raninid growth trends. Understanding this scaling also prevents features that are the same relative size, but present on carapaces of differing sizes, from being used as evidence of taxonomic dissimilarity. Pit size appears to be highly correlated with the amount of carapace growth; this trend can be marked on the carapace of a single specimen. Perforations observed in *Eumorphocorystes sculptus* and *Notopocorystes stokesi* exhibit much higher densities than closed pits observed in the bulk of the raninids. Unlike the pits without setae in the raninids, setal pits observed in *Callinectes sapidus* Rathbun, 1896, a portunid crab used for comparison, do not grow as the carapace expands during ontogeny. Observing growth of cuticle surface features provides a biologically meaningful way of separating classes of character states.

References

Adams A. & White A., 1848 – Crustacea. In: The Zoology of the Voyage of H. M. S. Samarang, 1843-1846. London. Adams, A. (ed.).

Binkhorst J. T. van, 1857 – Neue Krebse aus der Maestrichter Tuffkreide. *Verh. Naturhist. Ver. preuss. Rheinl. Westf.* 14: 107-110.

Haan W. de, 1833-1850 – Crustacea. In: *Fauna Japonica sive Description Animalium, quae in Itinere per Japoniam, Jussu et Auspiciis Superiorum, qui Summum in India Batava Imperium Tenent, Suscepto, Annis 1823-1830 Collegit, Notis, Observationibus et Adumbrationibus Illustravit.* P. F. von Siebold & J. Müller (eds.). Lugduni-Batavorum (=Leiden).

Linnaeus C., 1758 – *Systema Naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis* (edit. 10). Vol. 1. Holmiae (Stockholm), Laurentii Salvii.

Mantell G. A., 1844 – The Medals of Creation, Or, First Lessons in Geology, and in the Study of Organic

Remains. *Henry G. Bohn*, York Street, Covent Garden, London. 2: 457-1016.

Rathbun M. J., 1896 – The genus *Callinectes*. *Proceedings of the United States National Museum,* 18 (1070): 349-375.

Rathbun M. J., 1933 – Descriptions of new species of crabs from the Gulf of California. *Proceedings of the Biological Society of Washington*, Washington, 46: 147-150.

Sakai T., 1963 – Description of two new genera and 14 new species of Japanese crabs from the collection of His Majesty the Emperor of Japan. *Crustaceana*, Leiden, 5 (3): 213-233.

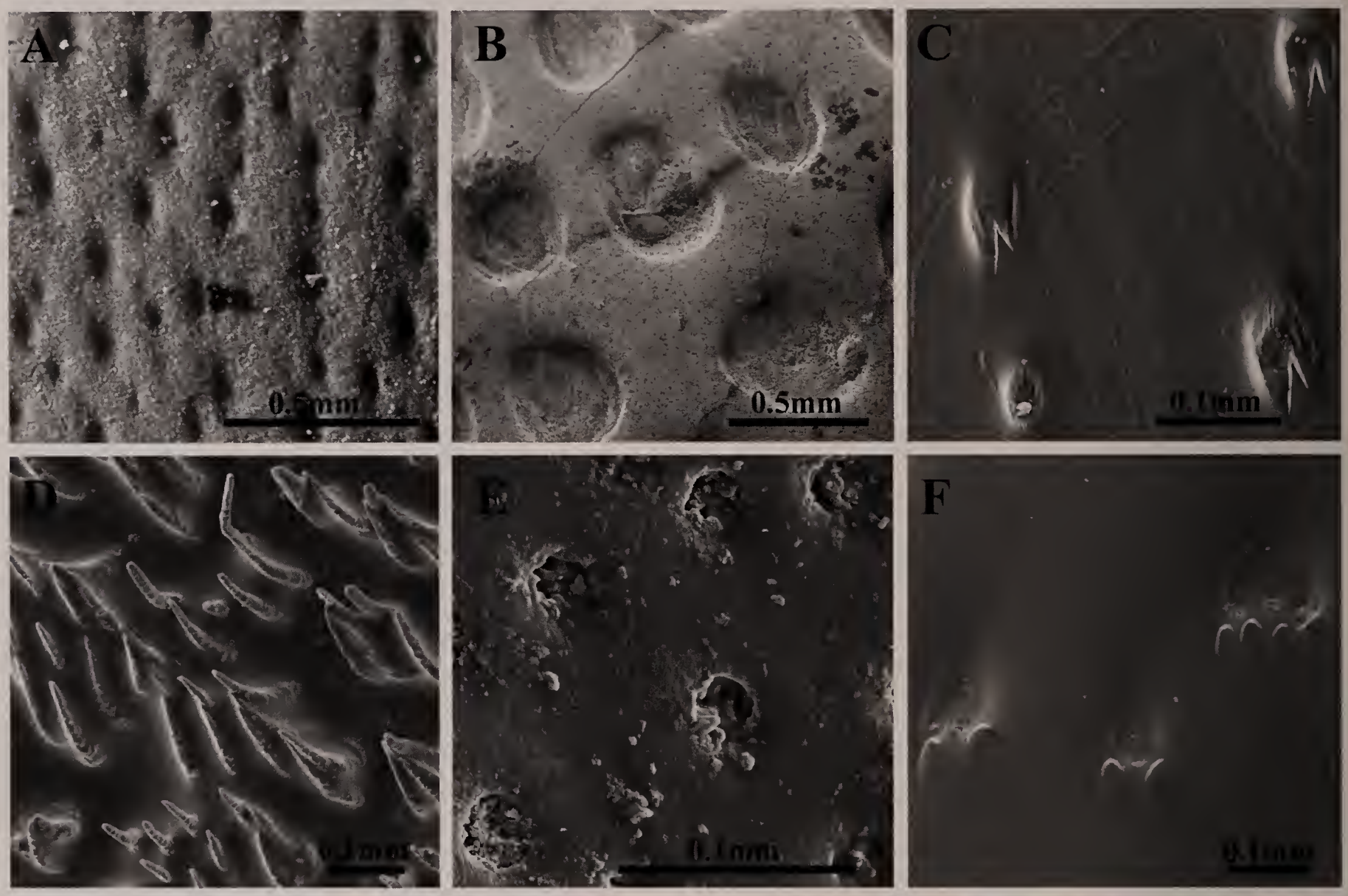

Fig. 1 - Pits observed on the surface of raninids. A) Simple closed pits, *Lyreidus tridentatus* De Haan, 1841, extant. B) Closed pits with defined sides, observed in *Macroacaena* sp., Eocene-lower Oligocene. C) Closed pits with undefined nodes, *Raninoides louisianensis* Rathbun, 1933, extant. D) Cast of setal hairs in *Umalia orientalis* (Sakai, 1963), extant, poor definition of seta due to limitations of casting technique and high magnification. E) Perforations, *Eumorphocorystes sculptus* Binkhorst, 1857, Cretaceous. F) Pits with setae and nodes, *Cosmonotus grayii* Adams and White, 1848, extant.

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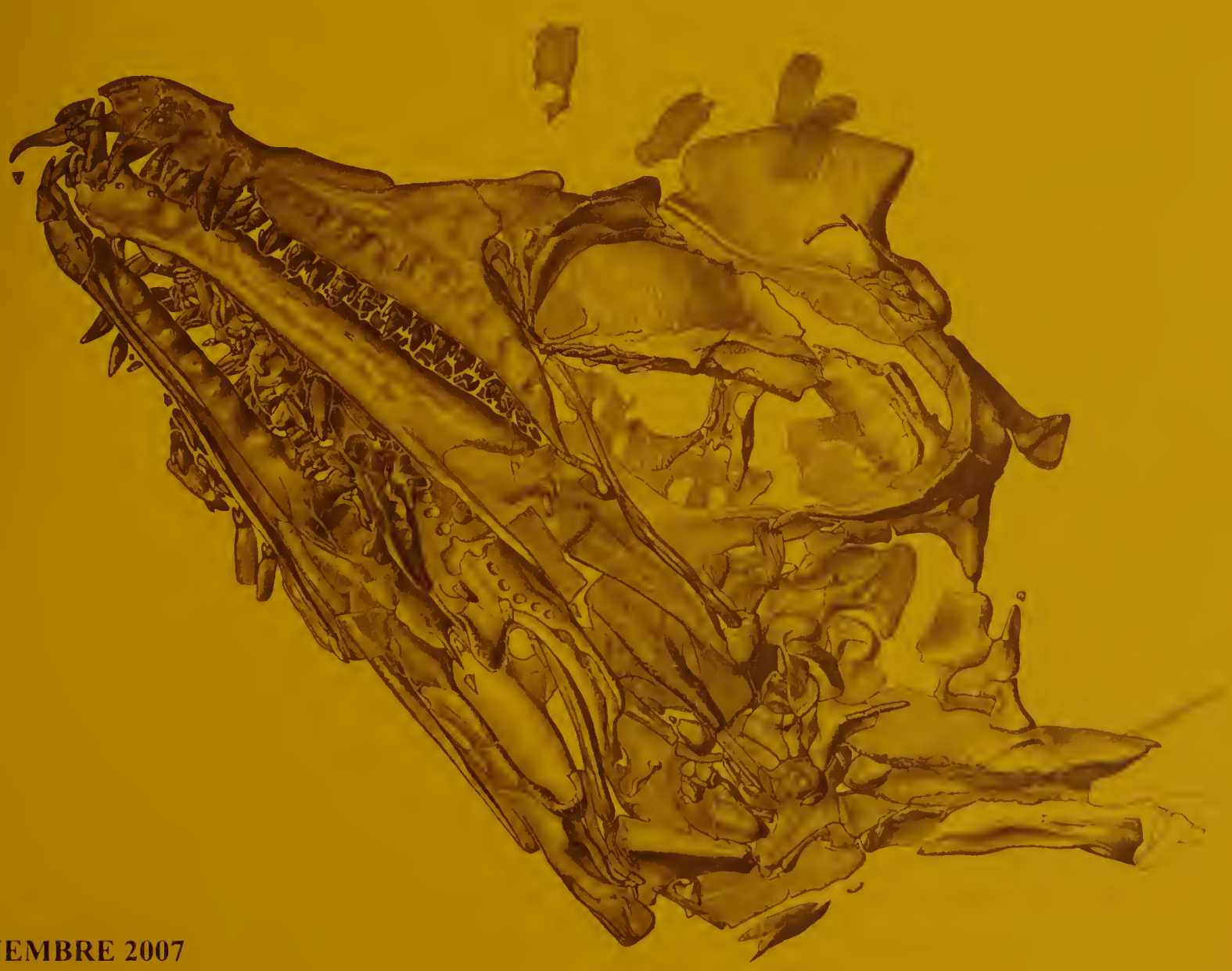

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In copertina: *Tanystropheus longobardicus*, MSNM BES SC 1018, skull. Watercolor by Massimo Demma.

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Stefania Nosotti

Tanystropheus longobardicus (Reptilia, Protorosauria): re-interpretations of the anatomy based on new specimens from the Middle Triassic of Besano (Lombardy, northern Italy)

This monograph is dedicated
to Giorgio Teruzzi and Anna Alessandrello,
for their unconditional trust and support
to Massimo Demma,
whose generosity, patience, dedication and extreme professionalism
made an important contribution to this publication
to Dr. Rupert Wild,
who established a milestone in Tanystropheus *research*

Abstract - After more than one century since the first report of *Tanystropheus longobardicus* from the Middle Triassic of Besano, new specimens from the same outcrops are described. These specimens include two articulated skeletons and an isolated pes, all from small-sized individuals, and fragmentary remains of larger individuals, i.e. a skull with some associated cervical vertebrae, an isolated dorsal vertebra and isolated cervical ribs.

This new material confirms the presence of *T. longobardicus* in the Besano Formation, which previously yielded few evidence. Moreover, it includes remarkably complete and well preserved specimens which provided the opportunity of a new interpretation of the anatomy of *Tanystropheus*, formerly described on the basis of a rich sample from the Swiss *Grenzbitumenzone*.

The description presented here applies to small-sized individuals of *Tanystropheus*, traditionally interpreted as the juveniles of *T. longobardicus*. However, the point is raised that they might represent the adults of a different species, demonstrating the presence of two taxa among the Swiss and Italian material referred to *T. longobardicus*. The holotype, and the single known specimen, of the small-sized *Tanystropheus meridensis* from the Meride Limestone is also considered and re-interpreted, leading to the conclusion that this species is probably a junior synonym of *T. longobardicus*.

Comparisons of the specimens of *Tanystropheus* from the Besano Formation with those from the equivalent *Grenzbitumenzone* helped to find the problematic elements of the classical reconstruction.

A new reconstruction of the skull of *Tanystropheus* is presented based on a three-dimensional clay model, with a re-interpretation of the pre-orbital region, the skull roof, and the lower jaw. The reconstruction of the temporal region of the skull is shown to be highly problematical. Finally, the new specimens confirm the presence of a sclerotic ring in *Tanystropheus*.

In the postcranial skeleton, the more important new information concern the morphology of the appendicular skeleton, which is remarkably well preserved in the new specimens. In particular, preservation of complete and perfectly articulated manus and pedes for the first time yields unequivocal evidence on their morphology.

The anatomy of the appendicular skeleton, in particular that of the hindlimb, is discussed in the context of locomotion mode. An overall view of previous studies on the mode of life of *Tanystropheus* is presented and discussed. According to these results, *Tanystropheus* should be regarded as a marine protorosaur, with close terrestrial ancestors, living in shallow waters. The feeding strategy of *Tanystropheus* is discussed, on the assumption that it likely was a slow, axial or paraxial swimmer with a stiff neck.

In conclusion, the new information obtained from the specimens described here is evaluated in the context of the recent cladistic analyses of protorosaurian relationships, highlighting the bearing of systematic anatomical work of original materials on the description and coding of phylogenetically informative characters.

Key words: *Tanystropheus*, *Tanystropheus longobardicus*, Middle Triassic, Besano, northern Italy, new specimens, *Tanystropheus meridensis,* anatomy, skull, pes, mode of life, systematic.

Riassunto – *Tanystropheus longobardicus* (Reptilia, Protorosauria): re-interpretazioni dell'anatomia basate su nuovi esemplari provenienti dal Triassico medio di Besano (Lombardia, Italia settentrionale).

A distanza di oltre un secolo dalla prima segnalazione di *Tanystropheus longobardicus* negli strati fossiliferi del Triassico medio di Besano (Varese), vengono qui descritti nuovi esemplari provenienti dai medesimi affioramenti. Si tratta di due scheletri in larga parte articolati e di un piede isolato ascrivibili ad individui di piccola taglia e di resti frammentari di individui di grandi dimensioni, in particolare un cranio associato ad alcune vertebre cervicali, una vertebra dorsale isolata e frammenti di coste cervicali.

Questo consistente nucleo di esemplari costituisce una ricca documentazione della presenza di *T. longobardicus* negli strati fossiliferi di Besano. Tale presenza era precedentemente testimoniata solamente dall'olotipo, distrutto nel corso della Seconda Guerra Mondiale, e da due esemplari frammentari conservati nelle Collezioni del Paläontologischen Institut und Museum der Universität, Zürich (PIMUZ). La completezza e l'ottimo stato di conservazione dei nuovi materiali consente una re-interpretazione dell'anatomia scheletrica di *Tanystropheus*, descritta nel secolo scorso sulla base di svariati esemplari affiorati sul versante svizzero del giacimento.

La nuova descrizione dell'anatomia di *T. longobardicus* qui presentata è applicabile ad individui di piccola taglia, che non superano i due metri di lunghezza complessiva. Nell'interpretazione classica, tali esemplari rappresenterebbero gli stadi giovanili della specie. Viene tuttavia avanzata l'ipotesi che in alternativa essi rappresentino gli adulti di una specie differente e che nel materiale italiano e svizzero proveniente dalla Formazione di Besano siano in realtà presenti due specie, l'una di piccola taglia, l'altra di taglia medio-grande. Viene anche preliminarmente re-interpretato l'olotipo, ed unico esemplare conosciuto, di *Tanystropheus meridensis*, proveniente dal Calcare di Meride, concludendo che esso è probabilmente sinonimo di *T. longobardicus*.

Il dettagliato confronto dei nuovi esemplari provenienti dalla Formazione di Besano con quelli dell'equivalente *Grenzbitumenzone* conservati nelle Collezioni del PIMUZ ha permesso di ottenere un'informazione più completa e di individuare gli aspetti problematici della ricostruzione classica.

Viene presentata una nuova ricostruzione del cranio di *Tanystropheus* ottenuta tramite la realizzazione di un modello tridimensionale. La regione pre-orbitale del cranio, il tetto cranico e la mandibola sono stati re-interpretati con risultati innovativi e ragionevolmente attendibili, mentre la ricostruzione della regione temporale, rivelatasi particolarmente problematica, resta ipotetica e viene pertanto proposta come un punto di partenza per ulteriori discussioni. I nuovi esemplari hanno tra l'altro definitivamente confermato la presenza di un anello sclerotico nell'occhio di *Tanystropheus*.

Circa lo scheletro postcraniale, gli esemplari di Besano hanno fornito nuove rilevanti informazioni. In particolare, l'eccezionale conservazione degli arti, unica nell'ambito di tutto il materiale conosciuto, ha permesso per la prima volta di accertare inequivocabilmente alcune delle loro caratteristiche anatomiche.

L'anatomia dello scheletro appendicolare, soprattutto del piede, viene interpretata in relazione alla locomozione terrestre ed acquatica. Questo, ed altri aspetti cruciali per l'interpretazione del modo di vita di *Tanystropheus,* vengono presentati e discussi, con un excursus che include anche gli studi più recenti e il confronto con altri vertebrati estinti ed attuali. Nell'interpretazione dell'autore *Tanystropheus* era un rettile marino nell'intero arco di vita, tuttavia non altamente specializzato per la vita acquatica in quanto strettamente imparentato con antenati francamente terrestri. Poiché *Tanystropheus* viene considerato un nuotatore lento dotato di un collo piuttosto rigido, uno degli aspetti più problematici nell'interpretazione del suo modo di vita rimane quello della strategia utilizzata per la cattura di prede presumibilmente molto sfuggenti. Contenuti stomacali a pesci e cefalopodi sono stati infatti rinvenuti in alcuni esemplari nelle Collezioni del PIMUZ.

Infine l'informazione inedita ottenuta con lo studio dei nuovi esemplari viene valutata nel contesto delle più recenti analisi cladistiche concernenti le relazioni filogenetiche dei protorosauri e si dimostra come in alcuni casi la descrizione e la codificazione dei caratteri siano basate su illazioni speculative presentate come dati certi, risultando di conseguenza errate e fuorvianti. Viene pertanto sottolineata l'importanza dello studio anatomico di materiale originale per una descrizione e codificazione accurata dei caratteri filogeneticamente informativi.

Parole chiave: *Tanystropheus*, *Tanystropheus longobardicus*, Triassico medio, Besano, Italia settentrionale, nuovi esemplari, *Tanystropheus meridensis,* anatomia, cranio, pes, modo di vita, sistematica.

INTRODUCTION

The genus *Tanystropheus* was erected by Hermann von Meyer (1847-1855) in 1852 (Quenstedt, 1963; Wild, 1976; I.C.Z.N., 1981), to comprise the species *T. conspicuus*, based on isolated bones from the Upper Muschelkalk of Bayreuth. These elements were interpreted by von Meyer as strikingly elongate caudal vertebrae of a reptile. Von Meyer did not explain the ethymology of the name *Tanystropheus*, which means "long ribbon", derived from the Greek "tany-"= prefix, meaning "long", "stretched" and "stróphos"= "strap", "rope", "ribbon", referring to the slender, elongate shape of the bones. According to von Meyer, the same bones had earlier been interpreted by Georg zu Münster as belonging to the limb of a new reptile, for which he had proposed the name *Macroscelosaurus* (with no indication of the relevant specific epithet, if any). However, von Meyer gave no reference to any publication by Münster. He introduced the name *Tanystropheus* maintaining that the name given by Münster was no longer accepted, with no further explanation. Since then, the name *Tanystropheus* has almost exclusively been used (Wild, 1976: 124), while only few authors (Broili, 1915: 51; Kuhn, 1934: 118) considered the use of the name *Tanystropheus* against the principle of priority, the senior synonym being *Macroscelosaurus*.

Oskar Kuhn (1934) referred to "*Macroscelosaurus* Münster, 1834" but no mention of *Macroscelosaurus* has ever been found either in the paper of 1834, or in any other known published paper by Münster (Kuhn, 1963: 5; Wild, 1974: 147; 1976: 124). Possibly, as suspected by Wild R. (pers. comm., 1998), Münster proposed the name in an unpublished private letter to von Meyer. Seemingly, von Meyer first published *Macroscelosaurus*, as a junior synonym of *Tanystropheus*. Following an application by Wild (1975; 1976), the International Commission on Zoological Nomenclature (I.C.Z.N., 1981) under its plenary powers conserved *Tanystropheus* von Meyer, [1852] as the valid name for the genus and suppressed *Macroscelosaurus* von Meyer, [1852]. Thus von Meyer was accepted as the author, and 1952 as the publication date of both names.

In 1886 Francesco Bassani reported a new reptile from the Middle Triassic of Besano (Varese Province, Lombardy, Italy), and named it *Tribelesodon longobardicus*, in reference to its tricuspid dentition. The specimen, housed in the Collections of the Museo di Storia Naturale di Milano, consisted of incomplete remains of a skull and some associated postcranial elements, preserved on a part and counterpart plate (Nopcsa v., 1923: 161, pl. II). Bassani gave a very short preliminary description of the specimen, which at the time was very poorly prepared (Peyer, 1931: 83), and tentatively concluded that it represented a flying reptile. As he did not include in his description any illustration, it is difficult to understand the reasons of his interpretation. Bassani also referred to a "second specimen" but Peyer (1931: 94) pointed out that a second *Tribelesodon* specimen could not be located in Milano, and conjectured that the "second specimen" was in fact a poorly preserved specimen of *Macrocnemus*. Bassani never published the monographic description of *Tribelesodon*, and for more than fifteen years the reptile from Besano lay almost forgotten in the Collections of the Museo di Storia Naturale di Milano.

The first detailed study of the holotype of *Tribelesodon longobardicus* was undertaken by Franz von Nopcsa in

1902 and 1904, and supported by grants from the Wiener Akademie der Wissenschaften (Nopcsa v., 1923: 161). The results of the study, and the photographs of the specimen were not published until 1923.

In the meantime, Gustav von Arthaber (1921) published a short description and a preliminary reconstruction of the skull of *Tribelesodon*. Von Nopcsa provided von Arthaber with a photograph of the skull, that was also published. At that time *Tribelesodon* was still considered a flying reptile. Later, von Arthaber (1922: fig. 3 a) published a composite photograph of the whole specimen, obtained by overlapping the negatives of the part and counterpart taken by von Nopcsa in 1902 (Nopcsa v., 1923: 161), and the reconstruction of the skull already published in 1921.

Von Nopcsa (1923) continued to consider *Tribelesodon* as a flying reptile (Nopcsa v., 1923: fig. 6). His reasoning based on the interpretation of some problematic, very elongate bones as segments of a forelimb with a long digit that he presumed supported a wing membrane. Once this assumption had been made, it influenced von Nopcsa's interpretation of many of the other preserved elements. Even so, von Nopcsa did consider the possibility that the problematic bones could be elongate vertebrae, similar to the cervical vertebrae of the pterosaur *Doratorhyncus*, or to the caudal vertebrae of *Tanystrophaeus* (sic!) from the Upper Muschelkalk of Bayreuth. However, he ultimately rejected these latter possibilities.

In 1927 additional remains of *Tanystropheus* were found in the *Grenzbitumenzone* of Monte San Giorgio (Cava Tre Fontane, Switzerland). These remains, thought to belong a single individual, comprised a few bones preserved on two plates. Later, in 1929, Bernard Peyer's excavations in the *Grenzbitumenzone* of Monte San Giorgio (Valporina, Switzerland) yielded the first almost complete small skeleton of *Tanystropheus* (neotype, i.e. specimen PIMUZ T 2791), together with other fragmentary specimens.

In 1931 Peyer published the description of all this new material. On the basis of the complete specimen he was able to identify the problematic elongate bones of *Tanystropheus conspicuus* from the Upper Muschelkalk of Bayreuth as cervical vertebrae. At the same time, after a close re-examination of the holotype of *Tribelesodon*, Peyer showed that *Tribelesodon* and *Tanystropheus* were congeneric, and he referred all the specimens from Besano and Monte San Giorgio to the same species: *Tanystropheus longobardicus*. Peyer proposed amending the diagnosis of the genus *Tanystropheus* - up to then based solely on the isolated vertebrae of *T. conspicuus* - and designating *T. longobardicus* as the type species. Moreover, he suggested designating the complete skeleton (specimen PIMUZ T 2791) and the whole material found in 1929 (sic!) as the neotype of *T. longobardicus*. Wild (1974: 148, 151) correctly argued that both proposals had to be rejected, the type species of the genus *Tanystropheus* being *T. conspicuus* by monotypy and the original type being at the time neither lost or destroyed (irrespective of the "neotype" designated by Peyer consisted of more than one specimen, therefore was *per se* invalid). In the light of the new discoveries, Peyer gave a re-description of the holotype of *Tribelesodon*. This remains the best account of this specimen, which was later destroyed by a fire caused by the bombing of the Museo di Storia Naturale di Milano during World War II. *T. longobardicus* was reconstructed by Peyer as a terrestrial reptile, probably living close to the water. He interpreted the long neck as an adaptation towards catching prey from the shore. Peyer proposed *Tanystropheus* as the unique representative of the "Tanysitrachelia" (Peyer, 1931: 89), a new suborder nested within the Sauropterygia (this group then including Trachelosauria, Nothosauria and Plesiosauria).

In 1974 Rupert Wild reviewed all the material of *T. longobardicus*, including both specimens published by Peyer in 1931, as well as undescribed ones resulting from later excavations conducted by Peyer and Emil Kuhn-Schnyder. On the basis of a total of 27 specimens - all but one housed in the Collections of the Paläontologisches Institut und Museum der Universität in Zürich (PIMUZ) - Wild (1974) described in detail the skeletal anatomy of *T. longobardicus*, with special emphasis on its skull, which had remained very poorly known after Peyer's description. In addition, he described the isolated vertebrae of *T. conspicuus* from the German Muschelkalk of Bayreuth. As the holotype of *Tribelesodon longobardicus* (=*Tanystropheus longobardicus*) had been destroyed, Wild could validly designate specimen PIMUZ T 2791 as the neotype of *T. longobardicus*. Wild (1974) gave a detailed description of the anatomy, ontogenetic development and the adaptation of *T. longobardicus*. He considered it to be terrestrial during juvenile stages but predominantly aquatic as an adult. Wild (1974) regarded *Tanystropheus* as a "highly specialized lacertilian", and included it in the Tanysitrachelida (1974: 147), as an infraorder of the "Lacertilia". Later, Wild (1980a) rejected the infraorder Tanysitrachelida in favour of the infraorder Prolacertiformes, the latter representing one of the two main branches of the Lacertilia (Wild, 1980a: fig. 13). The paper by Wild (1974) remains a benchmark study of *Tanystropheus*.

Since then, new species of *Tanystropheus* have been described (Jurcsák, 1975; Wild, 1980a; Rieppel, 2001), and fragmentary specimens have been referred to the genus (Jurcsák, 1976, 1978, 1982; Vickers-Rich *et al.*, 1999; Rieppel 2000, 2001; Dalla Vecchia & Avanzini, 2002; Dalla Vecchia, 2000, 2006; Sulej, 2004; Renesto, 2005), revealing a western Tethyan distribution and a stratigraphical occurrence from the lower Anisian to the late Norian.

The validity of the different *Tanystropheus* species is summarized below but a full revision of the genus is beyond the scope of this paper.

Wild (1980b: 204; 1987: 39) considered the possible synonymy of *T. longobardicus* and *T. conspicuus*. In addition, he questioned the validity of *T. biharicus* (Jurcsák, 1975), considering this species a probable junior synonym of *T. longobardicus* (Wild, 1980a: 12). Fraser & Rieppel (2006) recently erected *Amotosaurus rotfeldensis* for specimens from the Upper Buntsandstein of the Black Forest (Germany) previously assigned to "*Tanystropheus*" *antiquus* (Ortlam, 1967; Wild, 1980b; Wild & Oosternik, 1984). These authors also provisionally retained the status of *Tanystropheus antiquus* for the specimens from the Lower Muschelkalk of Poland, originally described by von Huene (1907-1908) but they questioned its validity. Renesto (2005: 386) questioned the assignment of *T. fossai* (Wild, 1980a) to *Tanystropheus*, maintaining that the holotype of *T. fossai* lacks unequivocal characters justifying its referral to that genus. Re-examination of the holotype of

T. meridensis (Wild, 1980a) led Fraser and colleagues (Fraser *et al.*, 2004; Fraser & Rieppel, 2006: 866) to the conclusion that this specimen cannot be distinguished from the smallest specimens of *T. longobardicus*, and they include it in this taxon. Detailed comparison of the skull of *T. meridensis* with the new specimens described here confirms the statement that *T. meridensis* and *T. longobardicus* should be considered conspecific (Fraser *et al.*, in preparation). Renesto (2005) recently described a new specimen (MCSN 4451) of *Tanystropheus* from Switzerland which, like *T. meridensis*, was collected in the Lower Meride Limestone of Ladinian age. However, due to the incomplete preservation of MCSN 4451, together with the uncertain status of the single specimen of *T. meridensis* (holotype: Wild, 1980a), Renesto preferred to consider the new specimen as *T.* cf. *longobardicus*. A preliminary personal examination of MCSN 4451, however, did not reveal striking differences from the new specimens, suggesting that it might well be referred to *T. longobardicus*. Interestingly, Fraser *et al.* (2004; contra Wild, 1974 and Tschanz, 1988) suggested that there might be two separate taxa represented in the material of *T. longobardicus* from the *Grenzbitumenzone* in the PIMUZ Collections but further studies are necessary. At present, *T. haasi* (Rieppel, 2001) is the only unquestioned species of the genus.

After the publication of the monograph by Wild (1974), several authors discussed, and sometimes drastically re-interpreted, both the adaptations of *Tanystropheus* (Tschanz, 1985, 1986, 1988; Rieppel, 1989; Taylor, 1989; Ford, 2002; Renesto, 2005) and its phylogenetic relationships (Benton, 1985; Evans, 1988; Gauthier *et al.*, 1988; Benton & Allen, 1997; Jalil, 1997; Dilkes, 1998; Peters, 2000a; Rieppel *et al.*, 2003). By contrast, little additional anatomical investigations have been undertaken, such that the descriptions given by Wild (1974; 1980a) remain the most complete ever published.

New, remarkably complete and well preserved specimens of *T. longobardicus* were collected in the 1990ies in sediments outcropping near Besano (Varese Province, Lombardy, Italy). These specimens, described in this paper, offer the first opportunity for new interpretations of the anatomy of *Tanystropheus* since Wild's (1974) monograph. The new material also documents the presence of *Tanystropheus* in the Middle Triassic of Besano. Very few and incomplete specimens were previously known from this locality. The holotype of *Tribelesodon longobardicus* (see above) is now lost, leaving just two more, very fragmentary specimens housed in the PIMUZ Collections (specimens PIMUZ T 2782 and PIMUZ T 2788, see Wild, 1974: tab. 1). Three of the new specimens can be referred to large-sized individuals, the first time that specimens equivalent in size to the larger specimens in the *Grenzbitumenzone* have been recorded in the Besano Formation.

INSTITUTIONAL ABBREVIATIONS

MCSN = Museo Cantonale di Scienze Naturali, Lugano, Switzerland.
MCSNB = Museo Civico di Scienze Naturali "E. Caffi", Bergamo, Italy.
MFSN = Museo Friulano di Storia Naturale, Udine, Italy.
MGB = Museu Geologia de Barcelona, Spain.
MSNM = Museo di Storia Naturale, Milano, Italy.
PIMUZ = Paläontologisches Institut und Museum der Universität, Zürich, Switzerland.
YPM = Yale Peabody Museum, New Haven, Connecticut, USA.

ANATOMICAL ABBREVIATIONS

a = angular
ac = atlas centrum
af = articular facet
afo = adductor fossa
ai = atlas intercentrum
ana = atlas neural arch
arf = articular fossa
art = articular
as = astragalus
at = anterior tubercle
axi = axis intercentrum
bo = basioccipital
bs + ps = basisphenoid-parasphenoid complex
c = cervical vertebra
ca = calcaneum
caf = capitular articular facet
cbI = ceratobranchial I
cc = *cristae cranii*
cd = caudal vertebra
ce = centrale
ch = chevron
cl = clavicle
co = coronoid
cor = coracoid
cr = cervical rib
cti = *cristae temporales inferiores*
d = dorsal vertebra
dc = distal carpal
de = dentary
dr = dorsal rib
dt = distal tarsal
e = epipterygoid
eo = exoccipital
f = frontal
fc = fibular condyle
fe = femur
fi = fibula
f-lf = lateral flange of the frontal
fm = foramen magnum
fp = *fossa parietalis*
g = gastralia
h = humerus
hs = horizontal shelf
i = ilium

icl = interclavicle
iob = impression of the olfactory bulb
is = ischium
j = jugal
l = lacrimal
lj-pp = lower jaw post-dentary part
ll = lateral lamina of the surangular
llo = lateral lobe of the main body of the frontal
lvm = latero-ventral margin
m = maxilla
Mca = Meckelian canal
mc = metacarpal
ml = medial lamina of the surangular
mlo = medial lobe of the main body of the frontal
mt = metatarsal
mth = maxillary tooth/teeth
n = nasal
nc = neural canal
ns = neural spine
of = obturator foramen
op = opisthotic
p = parietal
p-stp = supratemporal process of the parietal
pa = preatlas
pap = pre-acetabular process
pf = postfrontal
ph = phalanx
pl = palatine
ple = pleurapophysis
pl-mp = maxillary process of the palatine
plt = palatine tooth/teeth
pm = premaxilla
pmt= premaxillary tooth/teeth
po = postorbital
pra = prearticular
prf = prefrontal
prf-l = lobe of the prefrontal
prf-oa = orbital aspect of the prefrontal
prf-pp = palatine process of the prefrontal
prf-va = postero-ventral aspect of the prefrontal
prz = prezygapophysis
pt = pterygoid
pz = postzygapophysis
pzc = postzygapophyseal canal
pzp = postzygapophyseal process
pu = pubis
q = quadrate
r = radius
ra = radiale
raf = articular facet for the rib
s = sacral vertebra
sa = surangular
sb = sesamoid bone
sc = scapula
scp = sclerotic plate
so = supraoccipital
sp = splenial
sq = squamosal
st = supratemporal
stp = stapes
t = tibia
taf = tubercular articular facet
tc = tibial condyle
tp = transverse process
u = ulna
ul = ulnare
v = vomer
vk = ventral keel
vt = vomerine tooth/teeth

MATERIALS

All the new specimens described in this paper are housed in the Paleontological Collections of the Museo di Storia Naturale di Milano.

Five specimens come from the outcrops of the Besano Formation, or *Grenzbitumenzone* in the Swiss geological literature (Röhl *et al.*, 2001). On the basis of its ammonite fauna, Rieber (1973) referred the *Grenzbitumenzone* to the uppermost Anisian-lowermost Ladinian. One more specimen was collected in fossiliferous levels of the Meride Limestone of Ladinian age, which is separated from the Besano Formation by a dolomitic band (Furrer, 1995).

1) Specimen MSNM BES SC 265, *Tanystropheus longobardicus*.

Complete skeleton. Sasso Caldo (SC) quarry, Besano (BES), Varese Province, Lombardy, northern Italy. Besano Formation, Lower Ladinian (*curionii* Zone), Middle Triassic.

2) Specimen MSNM BES SC 1018, *Tanystropheus longobardicus*.

Incomplete skeleton. Sasso Caldo (SC) quarry, Besano (BES), Varese Province, Lombardy, northern Italy. Besano Formation, Lower Ladinian (*curionii* Zone), Middle Triassic.

3) Specimen MSNM V 3663 a b, *Tanystropheus longobardicus*, gift by Cesare Ferrario.

Incomplete skull and associated cervical vertebrae on a part and counterpart. Spoil from the Vallone mine, Besano, Varese Province, Lombardy, northern Italy. Besano Formation, Anisian-Ladinian boundary, Middle Triassic.

4) Specimen MSNM BES 215, *Tanystropheus* cf. *longobardicus*.

Isolated dorsal vertebra. Rio Ponticelli quarry, Besano (BES), Varese Province, Lombardy, northern Italy. Besano Formation, Anisian-Ladinian boundary, Middle Triassic.

5) Specimen MSNM BES 351, *Tanystropheus longobardicus*.

Cervical ribs. Spoil from the Vallone mine, Besano (BES), Varese Province, Lombardy, northern Italy. Besano Formation, Anisian-Ladinian boundary, Middle Triassic.

6) Specimen MSNM V 3730, *Tanystropheus* cf. *longobardicus*, gift by Sergio Rampinelli.

Pes, with partial natural mould and bone remains of the epipodials. Besano, Varese Province, Lombardy, northern Italy. Meride Limestone, Ladinian, Middle Triassic.

In addition, the material of *Tanystropheus longobardicus* in the PIMUZ Collections is re-examined.

METHODS

In the description of the materials the terminology of Wild (1974) is adopted (unless otherwise stated) in the description of processes, foramina and other anatomical details of each bone. New terms are introduced in quotation marks.

In describing elements of the pectoral and the pelvic girdles, the terms medial and lateral are adopted to differentiate between the two main surfaces, except for the interclavicle and the coracoids. The main surfaces of the latter elements are referred to as dorsal and ventral.

In describing limb elements, to avoid confusion in the terminology relative to their orientation, the adopted terminology is specified as follows. The normal position of the humerus and the femur is taken to be directed straight outwards from the body, with the dorsal surface correlated with the extensor musculature, and the ventral surface correlated with the flexor musculature. The side facing anteriorly is referred to as the anterior side, the side facing posteriorly is referred to as the posterior. As the precise orientation of the epipodial segment remains elusive, the normal position of this segment is arbitrarily taken to be one in which the epipodials lie side by side on a vertical plane perpendicular to the median sagittal plane. The surfaces that, in this position, face anterior or posterior are referred to as the anterior (extensor musculature) or the posterior (flexor musculature) surface of the bones. The side closer to the median sagittal plane is referred to as the medial, the other side as the lateral. Finally, the anatomical position of the manus and pes is taken to be one in which they point forward and are in contact with the ground. The surface in contact with the ground is referred to as the palmar and the plantar respectively (flexor musculature), the other one is referred to as the dorsal (extensor musculature). As is the case of the epipodials, the manus and pes have a medial and a lateral side. In describing movements of the ankle and the metatarsals, the terminology of Brinkman (1980) is adopted. Flexion of the ankle is meant to be a decrease in the angle at the ankle, and dorsiflexion of the metatarsus is a metatarsal movement associated with flexion of the ankle joint; extension of the ankle is an increase in the angle at the ankle, and plantarflexion of the metatarsus is a metatarsal movement associated with extension of the ankle.

Skeletal elements in the different specimens are briefly described under the heading of each specimen. An overall anatomical description, comparisons and discussion concerning the skull, the axial and appendicular skeleton are reported in the section "Discussion".

Specimens of *T. longobardicus* in the PIMUZ Collections have estimated overall lengths between 53 and 535 cm (Wild, 1974: tab. 1). Wild (1974) considered the small specimens to represent juveniles and the large ones adults of the same species, and conjectured that reproductive maturity corresponded approximately to a size of 2 m total length (on the basis of presence/absence of postcloacal bones and of the interpretation of the allometric growth curves). He considered certain differences in the dentition, the shape of the bones of the skull, and in the postcranial skeleton to be due to ontogenetic variation. Recently, Fraser *et al.* (2004) raised the possibility that the differences observed between the smallest and the larger individuals might instead be related to the presence of two separate taxa among the *Grenzbitumenzone* (=Besano Formation) material. Consequently, I will refer to the PIMUZ specimens as "small-sized" and "large-sized" specimens, rather than to juveniles and adults or even as two distinct species, pending the formal revision of taxonomy. Following Wild (1974), I maintain a demarcation size of approximately 2 m total length between small and large individuals, considering that individuals over 2 m lack distinct tricuspid teeth and dentition on the palatine and pterygoid.

See Tab. 1 for the correspondence of the letters used by Wild (1974) to designate the specimens in the PIMUZ Collections with their catalogue number. In the table, the specimens' overall length is also reported.

Table 1 – Correspondence of the letters used by Wild (1974) with the respective catalogue numbers in the *Tanystropheus longobardicus* specimens in the PIMUZ Collections, and overall length of each specimen. (* = estimated). After Wild, 1974: tab. 1.

Letter used by Wild	Number in PIMUZ Collection	Overall length (cm)
a	T 2791	87
b	T 2779	78*
c	T 2793	535*
d	T 2482	140*
e	T 2795	105*
f	T 2792	190*
h	T 2485	135*
i	T 2787	250
k	T 2817	295
l	T 2480	225*
m	T 2818	420
n	T 2782	160*
o	T 2780	85*
p	T 2790	335*
q	T 2819	365*
r	T 2484	100*
x	T 1270	210*
y	T 2789	330*

DESCRIPTION OF THE SPECIMENS

Specimen MSNM BES SC 265

(Figs. 1-9, 49 C-D, 54, 56 A, 58, 65, Pls. I-II, Tabs. 2-5, 8)

The specimen consists of an almost complete, and mostly articulated skeleton (Fig. 1, Pls. I-II), lying on its left lateral side. The skull is separated from the vertebral column, and is exposed in ventral view. The vertebral column is exposed in right lateral view, with some disarticulation and rotation in the sacral and proximal-caudal regions. Where disarticulated, the ribs are still in close proximity to the corresponding vertebrae. Gastral ribs cluster in the trunk region. The elements of the pectoral and pelvic girdles are disarticulated but still lie in an arrangement indicating their original position. The fore-

Fig. 1 – *Tanystropheus longobardicus*, MSNM BES SC 265. Scale bar 50 mm. Preparation: Sergio Rampinelli. Photo: Luciano Spezia.

limbs lie side by side ventral to the trunk, the right forelimb overlapping the left one. The right hindlimb has been raised as a consequence of the twisting of the vertebral column, while the left hindlimb lies ventral to the trunk. The estimated overall length of the specimen is 110 cm.

Skull
(Figs. 2-3, 49 C-D)

The complete skull is preserved in ventral view. Its length, measured from the tip of the left lower jaw (=estimated anterior extent of the premaxilla) to the posterior margin of the parietals, is 5.4 cm. As the parietals are displaced posteriorly, a more reliable estimate of the length of the skull might be the distance between the tip of the left lower jaw and the maximum posterior extent of the left squamosal, which is 5.1 cm.

The cranial elements are heavily crushed and elements of the neurocranium are randomly displaced posteriorly, thereby exposing the ventral surface of the parietals. The lower jaws rotated as a unit, with their anterior ends displaced to the right, and the posterior ends to the left, relative to the sagittal plane. Almost all the teeth of the upper jaws are still in situ, while the majority of the mandibular teeth are missing.

Premaxilla

The right premaxilla and part of the left one are concealed by the lower jaws. The area of contact between the right premaxilla and maxilla is not exposed. The left premaxilla still contacts the left maxilla but the suture between the two elements cannot be distinguished. Consequently, the number of premaxillary teeth cannot be ascertained. As in specimen MSNM BES SC 1018 the premaxilla bears six teeth (p. 21), I infer that the complete premaxillary dentition is seen on the left premaxilla of MSNM BES SC 265. The teeth are conical and have finely striated enamel. The tooth implantation is subthecodont (*sensu* Romer, 1956; Edmund, 1979; Wild, 1974; Motani, 1997; Zaher & Rieppel, 1999).

Maxilla

Both maxillae are preserved. The right maxilla is almost completely exposed in ventro-medial view, covered by the right lower jaw only very anteriorly. Only part of the jugal process is missing. The left maxilla is completely preserved and exposed in medial view but it no longer contacts the jugal. Almost all the ankylosed maxillary teeth, and/or the replacement ones, are preserved in situ on both maxillae. There are ten teeth in situ in the left maxilla and two empty alveoli anterior to them: the complete maxillary dentition then includes 12 teeth. The first unequivocally tricuspid tooth on the left maxilla is the seventh. The sixth has a distinct posterior cusp but only a very rudimentary anterior one. The fifth only has at best very rudimentary posterior cusp. Twelve teeth are also preserved on the right maxilla. In this case the first unequivocally tricuspid tooth is the fourth.

The raised lingual margins of the maxillae, dorsal to the teeth, should frame the choanae. The latter, however, cannot be clearly identified in the dermal palate.

Vomer

The vomers are entirely concealed by the lower jaws but in between the latter, some isolated vomerine teeth are exposed. They are very tiny and conical, with striated enamel.

Palatine

Both palatines are partially exposed. However, because of the poor preservation, no details can be discerned on left palatine. The maxillary process of the right palatine is clearly visible but it no longer contacts the maxilla. It shows a notched antero-lateral margin fram-

Fig. 2 – *Tanystropheus longobardicus*, MSNM BES SC 265, skull. Scale bar 10 mm. Photo: Luciano Spezia.

ing the choana postero-medially, and a weakly concave postero-lateral margin that framed the suborbital fenestra antero-medially. A conical tooth preserved on the left side is tentatively interpreted as a single palatine tooth.

Pterygoid

The right pterygoid exhibits the transverse process emerging close to the right lower jaw as a stout element, no longer contacting the ectopterygoid. Remnants of the quadrate process are possibly preserved further posteriorly, lateral to the parietal, and facing the right quadrate. No tooth-attachment sites can be identified. The left pterygoid could not be identified.

Ectopterygoid

No ectopterygoids could be identified in MSNM BES SC 265.

Frontal

Both frontals are partly exposed in ventral view, roofing the orbits with their horizontal lateral flanges (pp. 48-49).

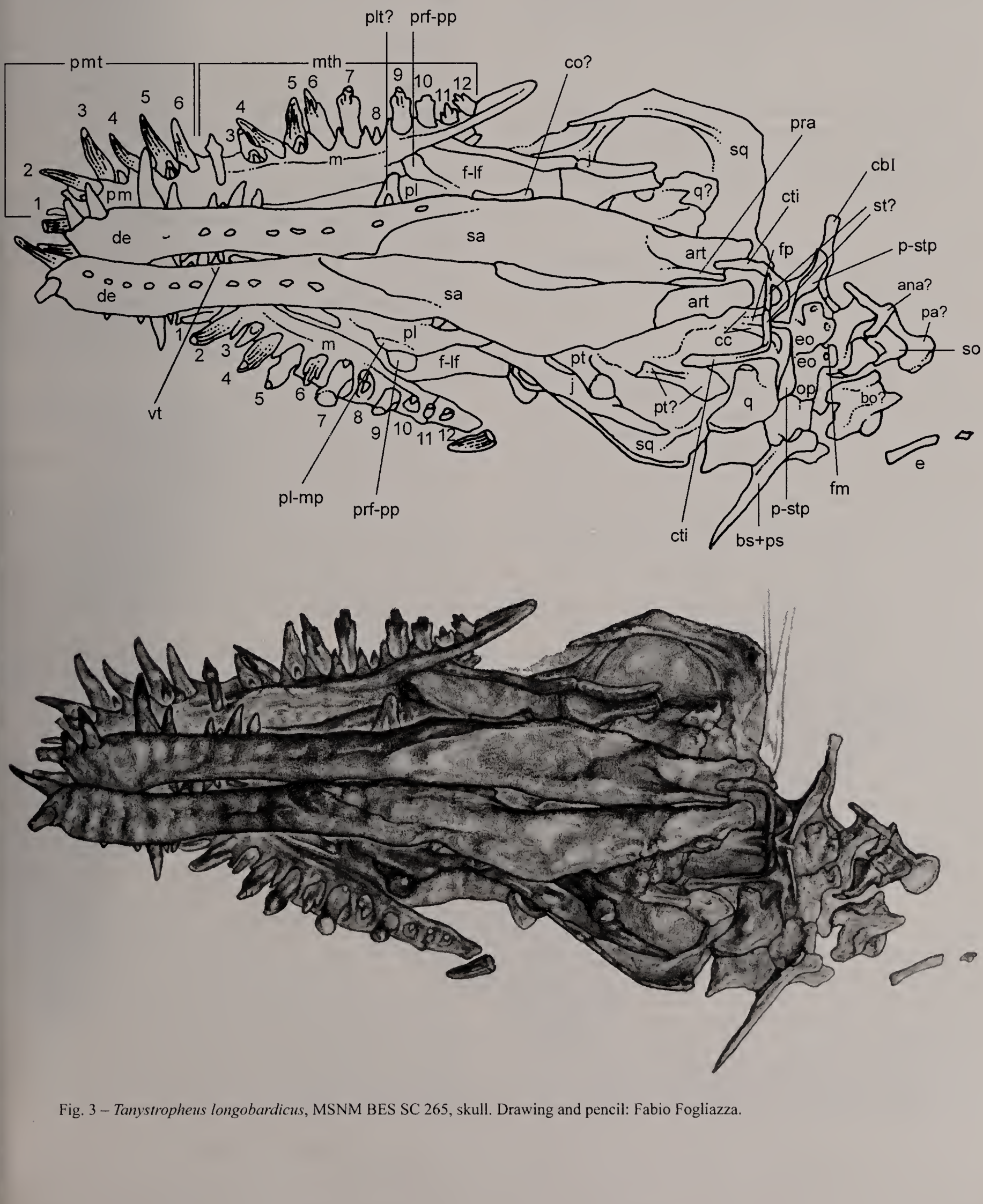

Fig. 3 – *Tanystropheus longobardicus*, MSNM BES SC 265, skull. Drawing and pencil: Fabio Fogliazza.

Parietal

Both parietals are broadly exposed in ventral view, and only partly concealed by the overlapping mandibles. Posteriorly, they are separated along their sutural contact. The morphological features of the ventral surface of the parietal plate that were described by Wild (1974: 11, fig. 2) can be clearly identified. A medial, narrow *fossa parietalis* is framed by the *cristae cranii*. They extend laterally and anteriorly into the *cristae temporales inferiores*. These in turn form the thickened lateral margin of the parietals. Posterior supratemporal processes project laterally at an angle of approximately 145°-150°. They bear an elongate facet for the reception of the squamosals and perhaps the supratemporals (see below).

Supratemporal

Paired small bony bars which overlap the parietals posteriorly might represent the supratemporals. However, because they are displaced, their relationships with the neighbouring bones are unclear and their identification remains equivocal.

Prefrontal

On the right and left side of the skull there are two protuberances which are here interpreted as the palatine processes of the prefrontals.

Squamosal

Both squamosals are preserved. The right squamosal is partly concealed by overlapping bones. The left squamosal is fully exposed. Anteriorly, it forms a sharply pointed postorbital process which is in close proximity to the jugal. Medially and posteriorly, the left squamosal is very broad, probably because of compression, and a parietal or supratemporal process cannot be clearly identified. The left squamosal does not meet the supratemporal process of the parietal but this is here considered to be an artefact of preservation.

The shape of the squamosal in MSNM BES SC 265 can be described as follows. The bone forms a "posterior ramus" projecting laterally from the skull roof. Then it sharply bends antero-laterally, forming an "anterior ramus". Where the bone bends, a ventrally projecting triangular lamina forms the quadrate process. At approximately two thirds of its length, the anterior ramus of the squamosal bends medially and tapers into the postorbital process. The ventral side of the squamosal is grooved.

Postorbital

No postorbitals could be identified in MSNM BES SC 265.

Jugal

Both jugals are preserved. The left one, exposed in lateral view, offers more anatomical detail.

The jugal has a triradiate shape, with a long and slender suborbital process (=maxillary process *sensu* Wild, 1974: 11) and two posterior processes: a slender, free-ending quadratojugal process extending posteriorly, and a broad, long postorbital process extending dorsally. The ventral margin of the jugal is strongly thickened, forming a ridge along the lateral surface of the bone. The lateral surface of the postorbital process exhibits an elongate, dorso-ventrally oriented groove.

Quadrate

The right quadrate is badly crushed and few details can be discerned. It is considered to be exposed in lateral view, with the articular condyle facing the lower jaw and the cephalic condyle facing the quadrate process of the squamosal. Only remnants of the left quadrate were tentatively identified on the left side of the skull.

Epipterygoid

An isolated, slender bony rod lying posterior to the elements of the neurocranium is interpreted as an epipterygoid (Wild, 1974: 14, figs. 1, 8 b). Its presumed ventral end is broken but clearly expanded.

Ceratobranchials

Lateral to the left exoccipital is a ceratobranchial I (Wild, 1974: figs. 21, 87). The expanded proximal end of the bone is directed laterally.

Neurocranium

Elements of the neurocranium are randomly displaced posterior to the parietals. As most of them are badly crushed and distorted, their interpretation must remain equivocal.

Both exoccipitals, fused to the partially preserved opisthotics, are exposed just posterior to the parietals, and still frame a very deformed foramen magnum.

The very poorly preserved supraoccipital lies further posteriorly, probably in occipital view.

The basisphenoid-parasphenoid complex is rather well preserved in ventro-lateral view. The cultriform process, projecting from the sphenoidal plate anteriorly, is distinct. The right alar process and the anterior part of the basisphenoidal plate were pushed outwards. The basipterygoid process is visible on both sides of the basicranium.

Posterior to the basisphenoid-parasphenoid complex lies a severely compressed and distorted element, which was tentatively identified as the basioccipital.

Lower jaw

The mandibular rami separated at the symphysis and shifted towards the median sagittal plane, so that they are both exposed in lateral view. The right mandibular ramus was probably stretched during fossilization, because it is a little longer than the left one. The mental foramina open at the bottom of small pits which are arranged in a series on the lateral side of the dentaries. The dentaries still bear some conical and sharply pointed teeth at a variety of developmental stages. The presence of poorly distinct cusps on the posteriormost preserved tooth on the left lower jaw remains equivocal. The dorsally convex suture between the dentary and surangular is present on both mandibular rami. The same is true for the sutures defining the articular; on the left side the prearticular is also identifiable, ventral to the articular. The presence of a coronoid remains uncertain (p. 61, Fig. 49).

Axial skeleton
(Figs. 1, 4-8, 54, 56 A, 58, Pls. I-II, Tabs. 2-3)

Cervical vertebrae and ribs (Figs. 4, 54, 56 A, 58, Pls. I-II, Tab. 2)

Twelve cervical vertebrae are preserved in right lateral view. Vertebrae two through eleven are complete. Only remnants of the atlas are preserved. Part of its right neural arch, is still articulated with the axis (Fig. 56 A). Two elements posterior to the parietals are tentatively interpreted as the remnants of the left atlas neural arch and the articulated proatlas (Fig. 3). These elements, however, are very poorly preserved. Moreover, the presumed proatlas is larger relative to the axis than the same element in MSNM BES SC 1018 (Fig. 12). The neural spine on the 12th vertebra (Fig. 4) is damaged and it is overlapped by the left scapula. Cervical vertebrae three through ten are deeply grooved because of the collapse of their bony walls inside the hollow vertebral centra (Wild, 1974: 81).

Cervical vertebrae two through twelve are still articulated, except for the eight and ninth element. At the joints between the 11th and the 12th cervical vertebrae and that between the 12th cervical vertebra and the first dorsal, the cervical vertebral column is bent backwards by almost 180° (Figs. 1, 4, Pls. I-II). It is no longer articulated with the skull.

Compression during fossilization makes it impossible to take reliable measurements of the vertebrae, apart from their length (Tab. 2).

The cervical ribs lie close together forming a thick, paired bundle that runs parallel to the cervical column along the cervical series seven through twelve (Fig. 1, Pls. I-II). Anterior to the seventh cervical, with the stronger dorsal bending of the cervical column, the rib bundle has

Table 2 – *Tanystropheus longobardicus*, length of the cervical vertebrae in MSNM BES SC 265 and MSNM BES SC 1018 (* = estimated; n. m. = not measurable).

Number of cervical vertebra	MSNM BES SC 265 Centrum length (mm)	MSNM BES SC 1018 Centrum length (mm)
2	13.8	17.0*
3	37.2	48.0*
4	40.5	59.8
5	40.0*	60.0*
6	41.8	59.7
7	46.1	69.8
8	57.3	82.8
9	62.0	89.3
10	57.9	n. m.
11	35.0	35.5
12	19.2	-

Fig. 4 – *Tanystropheus longobardicus*, MSNM BES SC 265, twelfth cervical vertebra and dorsal vertebrae one through three. Watercolor: Massimo Demma.

become detached from the vertebrae and projects forward in a straight line, while the cervical column is bent backwards. However, one of the ribs of the fourth pair and all the ribs of the first through third pairs follow the bending of the vertebral column, and lie randomly displaced to its left side. The ribs of the atlas and the axis cannot be distinguished from one another.

Dorsal vertebrae and ribs (Figs. 4-5, 7-8, Pls. I-II)

Thirteen dorsal vertebrae are preserved, some of them very poorly. Dorsal vertebrae one through eleven are exposed in right lateral view. The first dorsal is more or less in its original position relative to the 12th cervical (Fig. 4). The latter is tilted backwards, so that the zygapophyses of the two vertebrae are slightly shifted relative to each other. Dorsal vertebrae one through three (Fig. 4) and five through nine (Fig. 7) still form articulated series. The fourth dorsal is somewhat displaced relative to the preceding and the subsequent vertebrae. The tenth vertebra is exceptionally poorly preserved. The 12th and 13th dorsal vertebrae ("lumbars", Wild, 1974) are no longer articulated. The first is exposed in antero-lateral view, the second in right lateral view (Fig. 5). The pleurapophysis (*sensu* Wild, 1974; see note on p. 69) of the 12th dorsal is broken away and lies ventral to the 13th dorsal. It is not clear if it is complete. As preserved, it is 12.7 mm long and 1.3 mm deep.

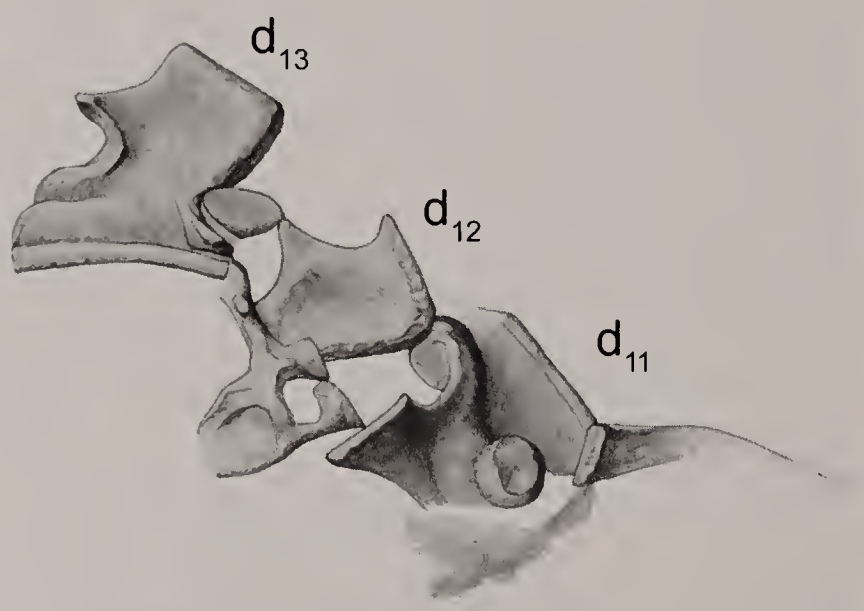

Fig. 5 – *Tanystropheus longobardicus*, MSNM BES SC 265, dorsal vertebrae eleven through thirteen. Watercolor: Massimo Demma.

Measurements of the centrum length are generally precluded because of poor preservation. The length of the second dorsal vertebral centrum, which is the best preserved of the dorsal series, is approximately 11 mm and that of the 11th is approximately 10 mm.

Few of the dorsal ribs are preserved. They are disarticulated and scattered but some of them still lie close to the corresponding vertebra. The ribs of the first and third pairs are dichocephalous (Fig. 4), while the remaining preserved ribs are holocephalous.

Sacral vertebrae (Figs. 6, 8, Pls. I-II)

Two sacral vertebrae are poorly preserved next to the right ilium and partly overlapped by the right femur. They exhibit stoutly built pleurapophyses (*sensu* Wild, 1974;

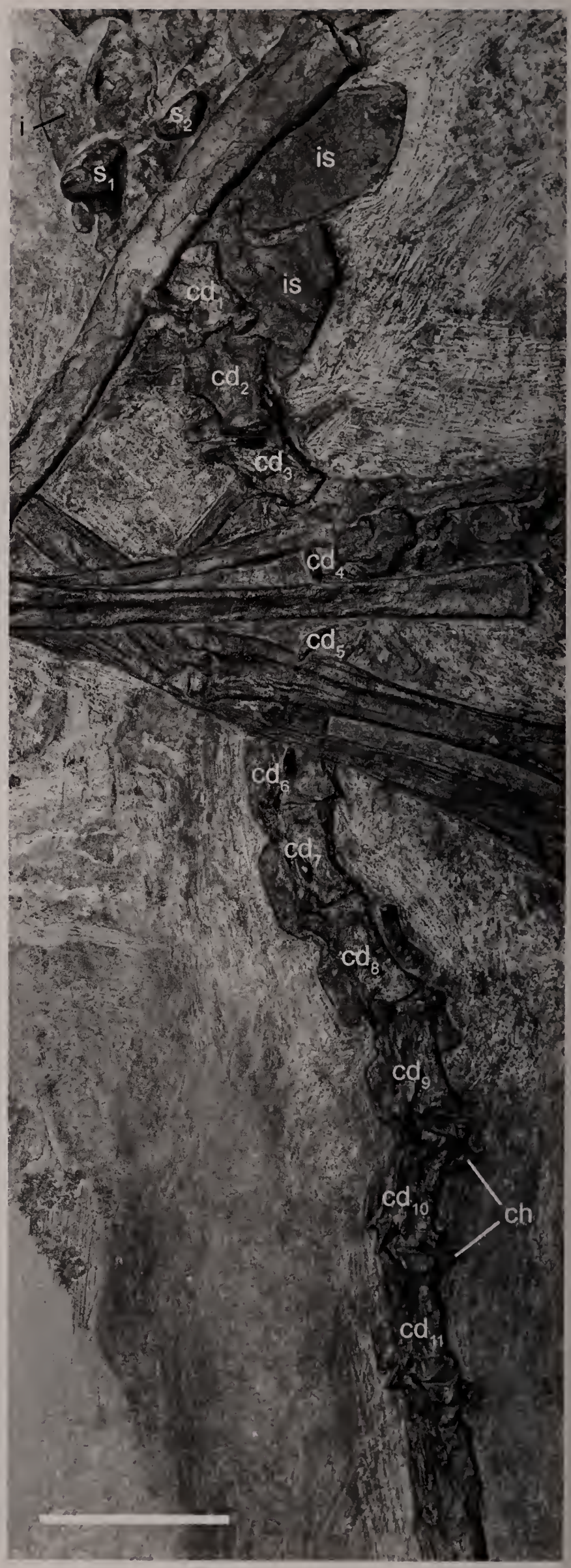

Fig. 6 – *Tanystropheus longobardicus*, MSNM BES SC 265, sacral and proximal caudal vertebrae. Scale bar 20 mm. Photo: Massimo Demma.

see note on p. 69). They remain articulated together but completely separate from the dorsal and the caudal series. The centra lie at right angles to the rest of the vertebral column, and are exposed in right lateral view. The pleurapophysis of the presumed first sacral is complete, while that of the presumed second sacral is probably truncated. The distal end of the complete pleurapophysis is greatly expanded and bears a wide triangular surface that contacted the ilium.

Caudal vertebrae (Figs. 1, 6, 8, Pls. I-II, Tab. 3)

The caudal series begins posterior to the right femur. It is estimated that there are at least 40 caudals (p. 70). With the possible exception of the vertebral pairs three-four, four-five, and five-six, the caudal vertebrae form a complete articulated series.

Caudals one through three (Figs. 6, 8) are damaged and deformed. The first caudal is poorly preserved in right lateral view. The distally truncated right pleurapophysis (*sensu* Wild, 1974; see note on p. 69) is crushed upwards and there is a remnant of the neural arch. The centra of the second and third caudals are partially rotated around their longitudinal axis and are exposed in latero-ventral view. The right pleurapophysis of the second caudal and both pleurapophyses of the third are preserved. The right pleurapophysis of the third caudal is 11 mm long and 2 mm deep. The right postzygapophysis of the second caudal and the corresponding prezygapophysis of the third are exposed in ventral view.

Distal to the third caudal, the series is exposed in right lateral view. The fourth and fifth caudals (Figs. 6, 8) are largely concealed by the overlapping bones of the right hindlimb and the cervical series. Remnants of their pleurapophyses project vertically out of the slab, indicating that these vertebrae lie on their left side. The distal end of the pleurapophyses of these vertebrae was probably broken away. Indeed there is a fragment of one such pleurapophyses preserved ventral to the fifth caudal.

Caudals six through eleven (Fig. 6) are very well preserved (the sixth one is, however, partially overlapped by the cervical ribs bundle). Distal to the 11th element, the caudals still form an articulated series (27.5 cm in length). The centra are the only preserved portion of these vertebrae, and the articulation between them is difficult to discern.

The measurements of the proximal caudal vertebrae of MSNM BES SC 265 are given in Tab. 3.

Table 3 – *Tanystropheus longobardicus*, length of the proximal caudal vertebrae in MSNM BES SC 265 (* = estimated; n. m. = not measurable).

Number of caudal vertebra	Centrum length (mm)
1	11.0*
2	10.0*
3	10.0*
4	n. m.
5	n. m.
6	n. m.
7	11.1
8	12.6
9	13.2
10	13.5
11	14.2

Gastralia

The gastralia randomly cluster in the trunk region. Few of them are preserved.

Appendicular skeleton
(Figs. 1, 7-9, 65, Pls. I-II, Tabs. 4-5, 8)

The most interesting features of the appendicular skeleton of MSNM BES SC 265 are the presence of sesamoid bones in the elbow and the knee joints, and the left tarsus, whose morphology is discussed on page 72.

Pectoral girdle (Fig. 7)

The elements of the pectoral girdle are displaced and only partially preserved and exposed. Only the right scapula and the interclavicle are missing.

The left scapula lies dorsal to the 11th and 12th cervical vertebrae and is exposed in lateral view. Its short peduncle bears the articular facet that contributes to the glenoid fossa. The antero-dorsal margin of the bone is heavily corroded but the posteriorly projecting process of the scapular blade is well preserved.

The coracoids are preserved ventral to the anteriormost dorsal vertebrae, partially overlapping each other. They are plate-shaped bones, with a short and stocky glenoid process. A supracoracoideal foramen is not clearly identifiable. The two coracoids are exposed in ventral view, because the articular facet that contributes to the glenoid fossa is visible. Thus, the more dorsal of the two is the left coracoid, shifted across the right one.

The clavicles are partially exposed ventral to the first dorsal rib. They are rod-shaped, curved elements offering little anatomical detail. The more ventral element might be the medial part of the left clavicle, and the other one the lateral part of the right clavicle (Wild, 1974: 103, figs. 65, 91).

Forelimb (Fig. 7, Tabs. 4, 8)

The forelimbs are fairly well preserved. However, some of their elements are missing and few anatomical detail of the preserved bones can be described. They lie side by side, the right limb uppermost and overlapping the left one. Because of the displacement of the bones of the pectoral girdle, the limbs are no longer articulated with the latter.

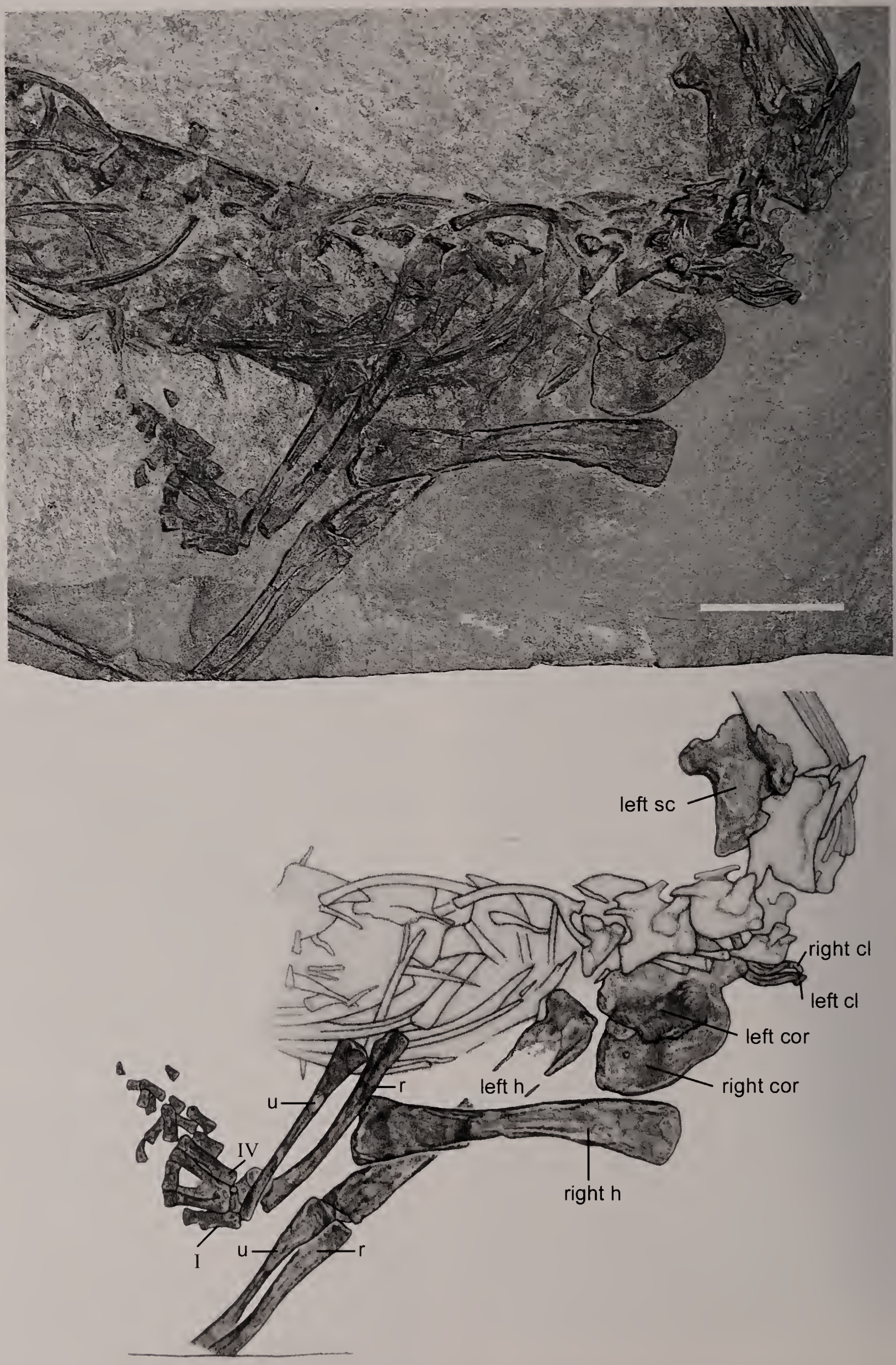

Fig. 7 – *Tanystropheus longobardicus*, MSNM BES SC 265, forelimbs. I-IV = Metacarpals. Scale bar 25 mm. Photo: Luciano Spezia. Pencil: Fabio Fogliazza.

The right forelimb (Fig. 7) is almost completely preserved. However, its elements are disarticulated and displaced relative to one another. The right humerus is preserved in dorsal view. The epipodials are no longer articulated with the humerus and are displaced more or less as a unit. Given the relative position of the radius and the ulna, the radius is preserved in anterior view and the ulna, probably, in antero-lateral view. The distal end of the ulna is displaced over that of the radius. The very poor preservation of the manus hinders its interpretation but it seems reasonable to assume that it is preserved in dorsal view. The manus is approximately in its original position relative to the forearm but no longer articulated with it. Only two elements of the carpus, possibly the ulnare and the medial distal carpal (homology unknown), are poorly preserved. Differently from metacarpals I-IV, metacarpal V cannot be reliably identified. Metacarpal I is displaced proximally and no longer aligned with the others. By comparison with MSNM BES SC 1018, all the phalanges are preserved but they are scattered, and their proximo-distal original sequence cannot be reliably reconstructed.

The left forelimb (Fig. 7) is not complete, because the distal ends of the epipodials and the manus are not preserved. The humerus - exposed in dorsal or dorso-posterior view - lies along the same longitudinal axis as the forearm, and is still articulated with it. A tiny sesamoid bone is identifiable in the elbow joint. The epipodials lie side by side exposed in anterior view. The proximal end of the ulna overlaps the radius, and its distal end is overlapped by the radius.

The proximal ends of the humeri have a flat articular surface. Distally, the ulnar condyle is more prominent than the radial one. The epipodials have slightly and equally expanded proximal ends, with flat or slightly convex articular surfaces. The ulnar margin of the radius and both margins of the ulna are concave.

Measurements of the elements of the forelimbs in MSNM BES SC 265 are given in Tab. 4. Length ratios between different elements of the forelimbs are given in Tab. 8.

Table 4 – *Tanystropheus longobardicus*, measurements of the forelimbs in MSNM BES SC 265 (n. m. = not measurable).

	Length (mm)	
	Right	Left
Humerus	50.3	49.5
Radius	35.3	n. m.
Ulna	32.8	n. m.

Pelvic girdle (Fig. 8)

The elements of the pelvic girdle are displaced and only partially preserved and exposed.

The elements of the right side of the girdle are all preserved and are thicker than the corresponding elements of the left side. They maintain their original position, having simply moved away from one another, and are exposed in lateral view. The ischium, and possibly the ilium - both exposed in medial view - are the only identifiable elements of the left side of the girdle.

The right ilium is well preserved, albeit partly concealed by the large pleurapophysis of the first sacral vertebra. The dorsal iliac blade projects far posteriorly, ending in a blunt tip. Anteriorly, it is short and rounded and it is delimited by a supra-acetabular buttress from the wide ventral acetabular fossa. As the acetabular fossa extends farther anteriorly than the dorsal blade, there is a waisted area between the two parts. A badly crushed and deformed element ventral to the 13th dorsal vertebra is tentatively interpreted as the left ilium. Two shallow fossae might represent facets for the sacral pleurapophyses.

The right pubis is largely concealed by the overlapping left ilium and only its ventralmost portion, antero-posteriorly expanded, is exposed.

The ischia lie posterior to the right femur. The right ischium is partly concealed by the overlapping caudal vertebrae. The anterior portion of the ischiadic plate and acetabular process is exposed. The left ischium is partly concealed by the overlapping right femur. The ventral portion of the ischiadic plate and part of the acetabular process are exposed.

Hindlimb (Figs. 8-9, Tabs. 5-8)

The hindlimbs of MSNM BES SC 265 are nearly complete and articulated. The left hindlimb lies ventral to the trunk, as expected for a dead animal lying on its left side. By contrast, as a result of the twisted sacral and proximal-caudal regions of the vertebral column, the right hindlimb has been raised and turned upside down. Because of the displacement of the bones of the pelvic girdle, the limbs are no longer articulated with the latter.

The right hindlimb (Fig. 8) is almost complete but its elements are partially disarticulated and displaced. The femur exposes its antero-ventral side. The articular surface on its proximal end is grooved. The distal end displays poorly differentiated condyles, the tibial condyle being slightly more prominent than the fibular one. The epipodials are no longer articulated with either the femur or the tarsus. They are preserved in medial, slightly anterior view. The proximal end of the tibia overlaps that of the fibula. Distally, the fibula was displaced posteriorly. The proximal and the distal ends of the tibia are slightly expanded and convex. The distal end of the fibula is not expanded. The pes is preserved in dorsal view. The only identifiable elements of the tarsus are the calcaneum and the astragalus (Fig. 9), the latter poorly preserved and displaced relative to the calcaneum. All the metatarsals are preserved; their proximal ends are no longer aligned, and metatarsal I is displaced medially. Metatarsals II through IV and some phalanges are partially concealed by the overlapping cervical vertebral column. By comparison with MSNM BES SC 1018, all the phalanges, except the ungual phalanx of digit five, were identified, and the phalangeal formula is 2,3,4,5,4. The phalanges are mostly disarticulated but their proximo-distal sequences can be still identified (Fig. 9).

The left hindlimb (Fig. 8) is better preserved than the right one. Its elements are all identifiable and only the distal phalanges of the digits are partially displaced. The femur is exposed in anterior view. The shaft is gently, sigmoidally curved. The proximal end is expanded and

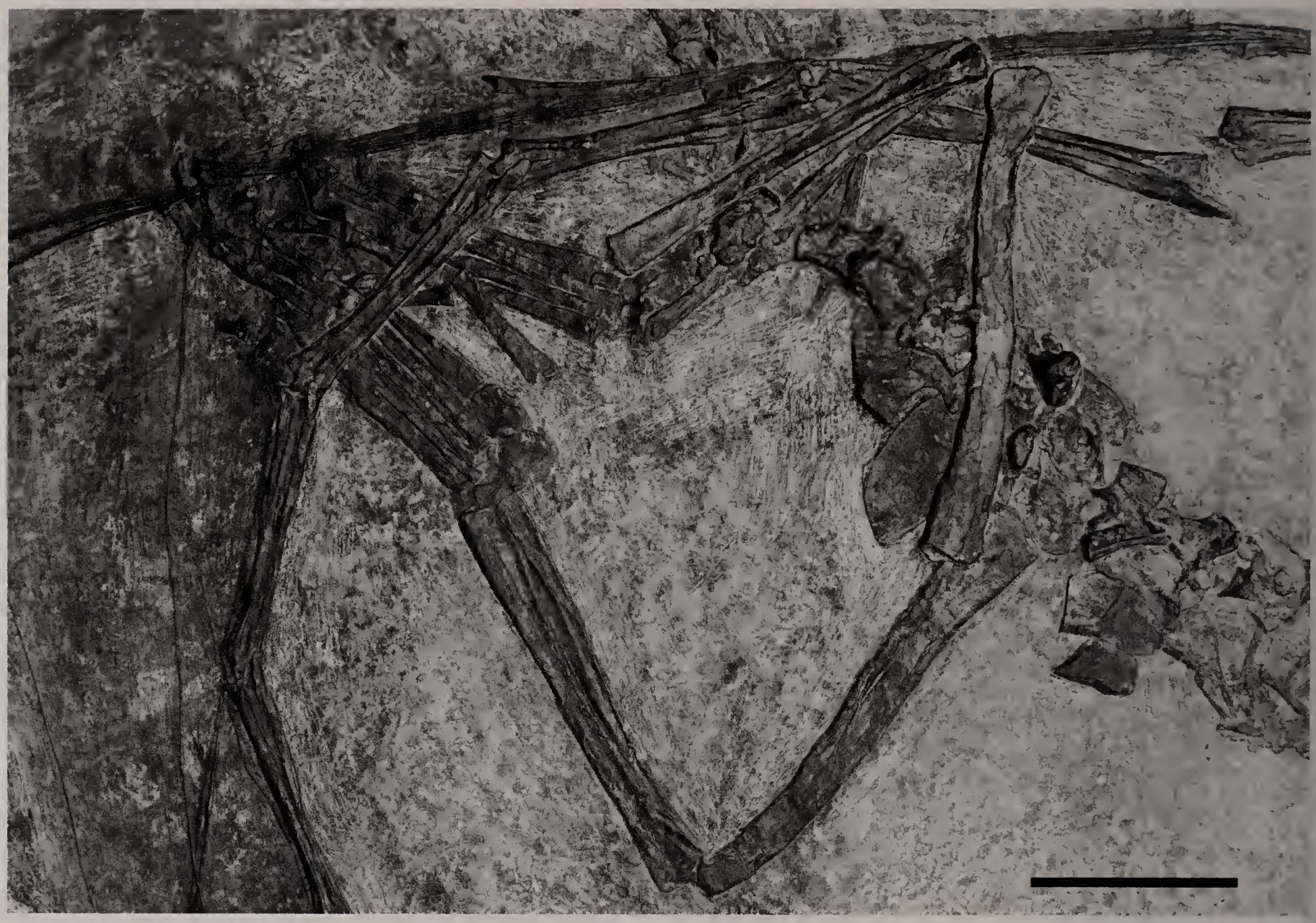

Fig. 8 – *Tanystropheus longobardicus*, MSNM BES SC 265, hindlimbs. Scale bar 30 mm. Photo: Luciano Spezia. Pencil: Fabio Fogliazza.

weakly convex. The distal end is deflected ventrally. Only the tibial condyle is exposed, and its rounded contour indicates that the articular surface for the tibia was sub-cylindrical in shape. The crus is still articulated with the femur, and rotated on its longitudinal axis together with the articulated pes. The crus is thus exposed in postero-medial view and the pes in plantar view. A small sesamoid bone is preserved in the knee joint. The tibia has expanded ends, with the proximal end flat, and the distal end slightly convex. The proximal end of the fibula is concealed by the tibia, but its weakly convex and not expanded distal end slightly overlaps the tibia. The pes is displaced laterally relative to the crus. The tarsus (Figs. 9, 65) comprises four ossified elements in close juxtaposition: astragalus, calcaneum, distal tarsal three and distal tarsal four. The astragalus and the calcaneum meet along a straight line and the astragalus slightly overlaps the calcaneum proximally with a lateral process. A foramen for the perforating artery (Wild, 1974: 116) cannot be identified. The astragalus is a rather stocky element, elongate transversally relative to the longitudinal axis of the crus. Distally it forms a shallow fossa. The calcaneum has a weakly polygonal shape. Distally, it articulates with metatarsal V. Distally and medially a line seemingly indicating a contact between the calcaneum and distal tarsal four (Fig 65) represents a crack at the bottom of a shallow fossa. The proximal margin of distal tarsal four is not distinct. As preserved, distal tarsal four partly overlaps the calcaneum (Fig. 9) and it is probably a larger element than it appears. Distal tarsal four contacts metatarsal V laterally and the proximal head of metatarsal IV distally. Distal tarsal three is displaced and overlaps distal tarsal four. The metatarsals and the phalanges are not greatly displaced relative to one another: metatarsal I through III are displaced proximally, and some phalanges are no longer articulated but their sequence in each digit remains clearly identifiable (Fig. 9). Metatarsals II through IV, and some phalanges of the digits are partially concealed by the overlapping cervical vertebral column. The proximal ends of the metatarsals overlap, each lateral element overlapping the medial one. By comparison with MSNM BES SC 1018, all the phalanges are preserved, the phalangeal formula being 2,3,4,5,4.

Measurements of the elements of the hindlimbs in MSNM BES SC 265 are given in Tab. 5. Length ratios between different elements of the hindlimbs are given in Tab. 8.

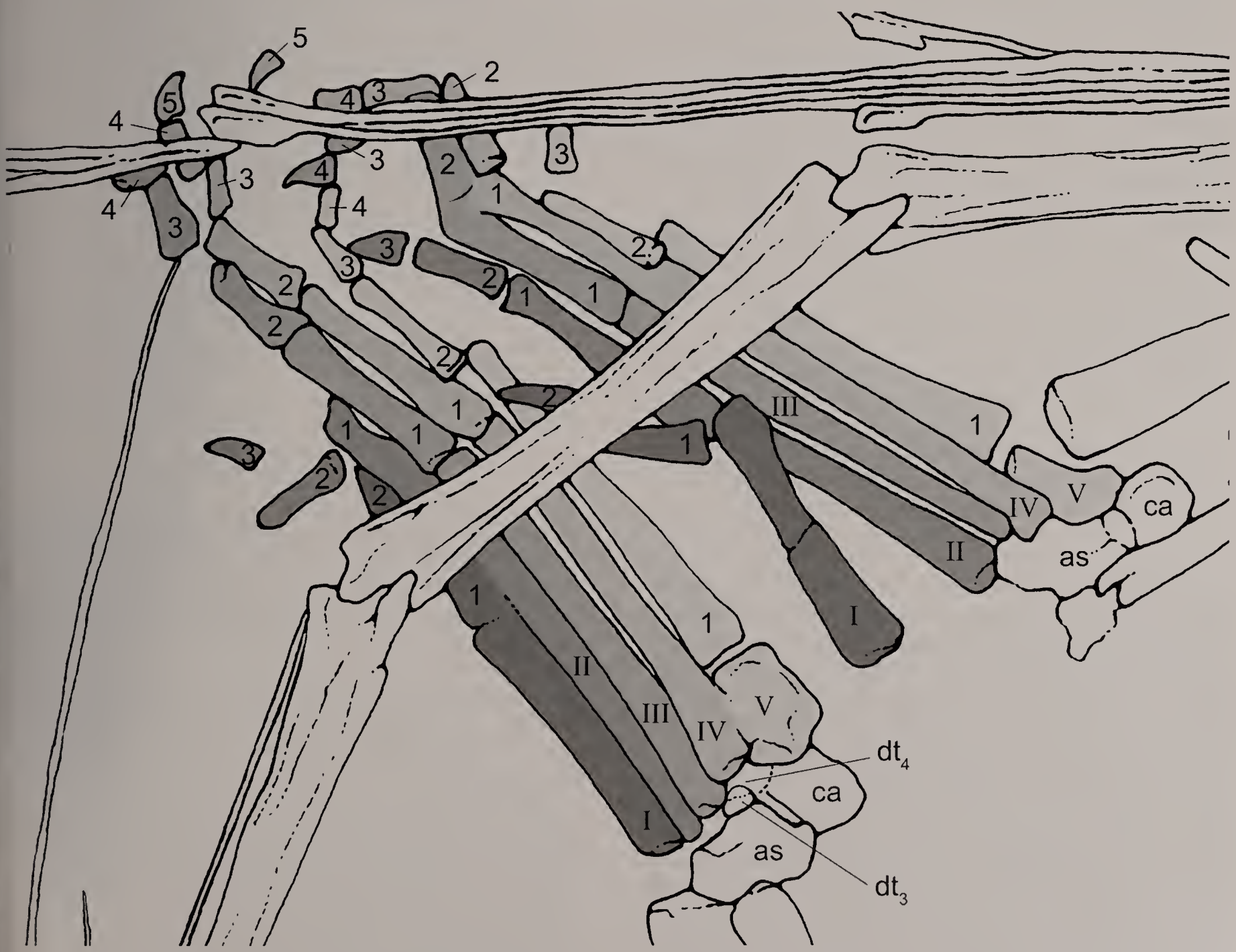

Fig. 9 – *Tanystropheus longobardicus*, MSNM BES SC 265, pedes. I-V = metatarsals. Drawing: Fabio Fogliazza.

Table 5 – *Tanystropheus longobardicus*, measurements of the hindlimbs in MSNM BES SC 265 and MSNM BES SC 1018 (* = estimated; n. m. = not measurable).

	MSNM BES SC 265		**MSNM BES SC 1018**
	Right hindlimb (mm)	Left hindlimb (mm)	Left hindlimb (mm)
Femur	72.5	70.8	n. m.
Tibia	61.4	62.1	74.2
Fibula	62.0*	58.0*	74.0
Metatarsal I	20.6	20.7	27.8
Metatarsal II	n. m.	n. m.	34.6
Metatarsal III	31.4	30.8	37.7
Metatarsal IV	32.0*	29.0*	36.4
Metatarsal V	8.0*	8.5	11.1
	Digit I		
Phalanx I	n. m.	14.43	13.6
Ungual	n. m.		5.7
	Digit II		
Phalanx I	n. m.	n. m.	14.3
Phalanx II	7.3	7.4	9.3
Ungual	n. m.	4.9	5.5
	Digit III		
Phalanx I	14.0	13.0*	17.2
Phalanx II	7.0	7.0*	8.9
Phalanx III	n. m.	6.0*	7.2
Ungual	4.5	4.0*	5.1
	Digit IV		
Phalanx I	n. m.	15.9	19.5
Phalanx II	7.7	7.6	9.3
Phalanx III	4.7	4.7	5.6
Phalanx IV	3.8	3.6	4.4
Ungual	3.0*	3.1	3.7
	Digit V		
Phalanx I	28.7	27.8	34.6
Phalanx II	9.5	9.1	12.4
Phalanx III	n. m.	4.4	5.6
Ungual	n. m.	3.0	3.4

Specimen MSNM BES SC 1018
(Figs. 10-29, 49 E, 53 B, 54, 56 B, 59, 62, Pls. III-IV, Tabs. 2, 5-6, 8)

The specimen consists of a partially articulated and beautifully preserved skeleton lying on its right lateral side. The skull is not properly articulated with the neck, because the occipital elements are displaced but lies next to it. The neck is tilted backwards and is separated from the trunk. However, cervical vertebrate two through ten form an articulated series, except for a separation of the fourth from the fifth. The trunk region comprises a series of dorsal vertebrae, isolated dorsal ribs, and clustering gastral ribs. The preserved proximal caudal vertebrae are scattered on the slab, while some of the distal caudals are articulated and form two isolated series. The pectoral girdle with both forelimbs, and the left pelvic girdle with the left hindlimb, clearly lie in their original position relative to the trunk. The right pelvic girdle and hindlimb are disarticulated, and their elements randomly displaced. The estimated overall length of the specimen is 140 cm.

Skull
(Figs. 10-13, 49 E, 53 B)

In spite of incomplete preservation, the skull of MSNM BES SC 1018 provides some superb anatomical details, and probably represents the best example of the overall morphology of the skull in all of small-sized specimens of *T. longobardicus* to date. It is exposed in left ventro-lateral view, so that both mandibular rami are exposed, the left one in lateral view, the right one in medial view. The length of the skull from the anterior end of the left premaxilla to the posterior end of the left lower jaw is 5.8 cm.

The skull is crushed, and the majority of bones are displaced to a variable degree. In particular, many of the unidentified elements are randomly displaced posteriorly. By contrast, elements preserved in the antorbital region are still mostly articulated. Dermal bones completing the circumorbital series, and forming the skull roof are only slightly displaced. Dermal bones of the palate are partly exposed in between the mandibular rami. The lower jaws

are complete and in situ. Almost all the teeth of the upper and lower left jaws are in situ, while those of the right side are mostly displaced.

Premaxilla

Only the left premaxilla is exposed but it is complete. It possesses a long and slender maxillary process contacting the dorsal margin of the maxilla, and a short but clearly delimited nasal process. Posterior to the nasal process, the entire dorsal margin of the premaxilla is free, and presumably framed the external naris latero-ventrally (Figs. 36-37). Tiny foramina open anteriorly on the dorsolateral surface of the premaxilla, possibly transmitting branches of the medial ethmoidal nerve (Oelrich, 1956).

The premaxilla possesses six teeth - five of which are preserved in situ - most probably representing the complete premaxillary dentition. The teeth are long, conical and slightly recurved, with finely striated enamel. The third one is the longest. The premaxillary teeth interlock with the anteriormost dentary teeth of the lower jaw.

Maxilla

Only the left maxilla is exposed. It is complete, and still articulated with the premaxilla. It is a triangular bone, bifurcating posteriorly into a long, tapering ventral jugal process, and into a shorter, yet well developed, dorsal process (*processus frontalis*, *sensu* Wild, 1974: fig. 2). The emarginated region between the two processes receives the lacrimal. Dorsal to the lacrimal, the posterior margin of the dorsal process contacts the prefrontal. The dorsal margin of the jugal process no longer contacts the jugal. Posterior to the contact with the maxillary process of the premaxilla, the dorsal margin of the maxilla is free. Originally, it presumably articulated with the nasal (p. 46).

Fourteen maxillary teeth are preserved in situ. A gap between the two posteriormost teeth suggests that the full maxillary tooth count might be of 15. All the maxillary teeth are tricuspid. The lateral surface of the maxilla exhibits a series of shallow fossae laterally delimited by bulges. Each of these fossae corresponds to a tooth position.

Vomer

Remnants of the vomer are tentatively identified anterior to the right palatine but because of very poor preservation they provide no further detail. However, some isolated teeth are interpreted as vomerine teeth. They are tiny and pointed, with striated enamel.

Palatine

Anterior to the pterygoid, two more dentigerous bones are interpreted as the palatines. The element that lies immediately anterior to the pterygoid, with four large alveoli (diameter approximately 1.4 mm), is interpreted as the left palatine exposed in ventral view. It still contacts the pterygoid, albeit probably slightly displaced (the anteriormost tooth position of the pterygoid is partly covered with bone). The maxillary process is apparently crushed against the dentigerous region of the bone. The element anterior to the left palatine is interpreted as the right palatine exposed in ventral view. It also exhibits four tooth alveoli approximately as large as those of the left palatine. None of the preserved isolated teeth were identified as palatine teeth.

Pterygoid

Only the left pterygoid is exposed between the mandibular rami, and it is preserved in ventral view. It shows a well developed transverse process, and a slender, tapering quadrate process. It bears a row of at least 12 tooth positions whose diameter becomes smaller posteriorly (from approximately 0.9 to 0.7 mm). No pterygoid tooth is preserved in situ, and I was not able to single out pterygoid teeth among the isolated preserved teeth.

Ectopterygoid and Nasal

No ectopterygoids or nasals could be identified in MSNM BES SC 1018.

Frontal

Both frontals are well preserved, albeit separated.

The left frontal rotated upwards on its longitudinal axis, exposing the ventral side. It exhibits a large axe-shaped lateral flange, which is medially delimited by a prominent, sinuously curved ridge. Therefore, the flange is concave near the median sagittal plane, and deepened into the cranial cavity. The anterior, lateral, and posterior margins of the flange are free. Medial to the lateral flange, the main body of the left frontal extends between the sinuous margin bordering the lateral flange and a straight, yet irregular, medial margin originally contacting that of the right frontal. The anterior end of the main body of the frontal is bifurcate, with a lateral and medial lobes interlocking with the prefrontal. A notch in the anterior margin of the lateral flange demarcates laterally the anterior end of the main body of the frontal. Posteriorly, the left frontal still contacts the parietal but the latter is badly crushed and provides no information about the nature of the contact between the two bones.

The right frontal is displaced into the orbit as an isolated element, and it is exposed in dorsal view. Its lateral flange is partly concealed by the left frontal and prefrontal. The main body of the right frontal is thick, and raised above the lateral flange. As in the left frontal, a notch between the anterior end of the main body of the frontal and its lateral flange is distinct. A notch in the postero-medial end of the right frontal is interpreted as the antero-lateral margin of the parietal foramen (p. 51).

Parietal

Both parietals are preserved. The left one is crushed and broken into small pieces although is approximately in its original position, posterior to the left frontal. The right parietal, exposed in ventral view, is displaced, yet still in close proximity to the right frontal. Posteriorly it is overlapped by the left postorbital. Its straight lateral margin is only slightly thickened. Its straight medial margin (*crista cranii, sensu* Wild, 1974: fig. 2) and oblique antero-medial margin are thickened. Posteriorly, the antero-medial margin is recessed into a subtriangular fossa which bordered the parietal foramen postero-laterally.

Supratemporal

No supratemporals could be identified in MSNM BES SC 1018.

Fig. 10 – *Tanystropheus longobardicus*, MSNM BES SC 1018, skull. Scale bar 10 mm. Photo: Luciano Spezia.

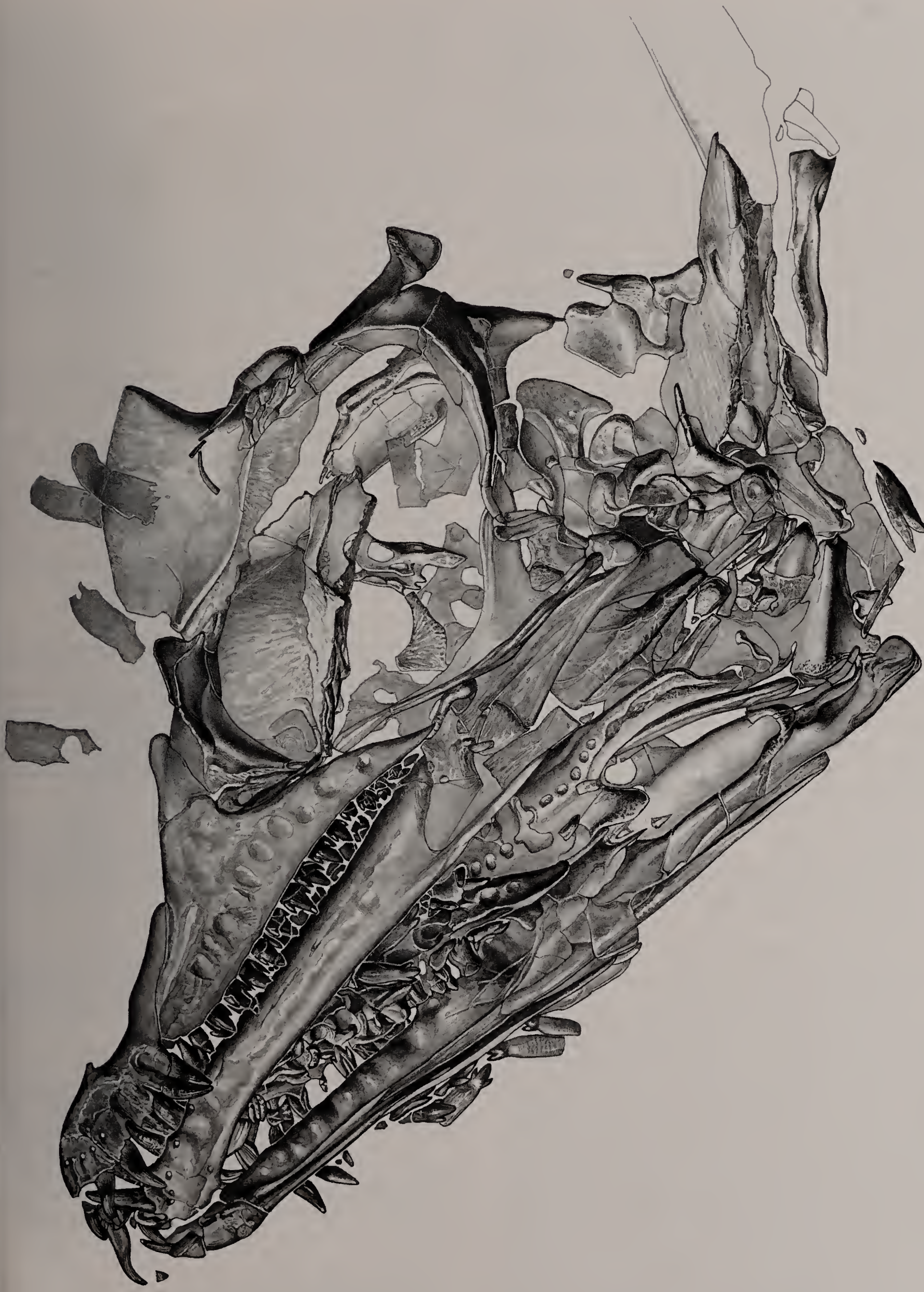

Fig. 11 – *Tanystropheus longobardicus*, MSNM BES SC 1018, skull. Watercolor: Massimo Demma.

Prefrontal

Only the left, completely preserved, prefrontal is exposed. The strong compression renders the interpretation of its complex three-dimensional shape difficult (p. 52, Fig. 37). I assume that the posteriormost part of the prefrontal rotated upwards on a longitudinal axis together with the frontal, thus exposing the postero-ventral aspect.

The prefrontal is a large bone extending dorso-ventrally between the skull roof and the lacrimal, and forming almost entirely the anterior margin of the orbit, as well as its anterior wall. Dorsally, the prefrontal contacts the frontal with a frontal process fitting into the bifurcate anterior end of the main body of the frontal. Ventrally, the prefrontal is slightly shifted relative to the overlapping lacrimal, and the facet receiving the lacrimal is clearly visible. Anteriorly, the prefrontal contacts the dorsal process of the maxilla.

Laterally, the prefrontal develops a sinuous crest close to the orbital margin, which is dorsally expanded into a rounded "lobe" (p. 51). In the fossil, this lobe was raised and is exposed in ventral view. The dorsalmost part of the prefrontal, medial to the crest and facing anteriorly, is not visible.

Nothing can be said about the presumed contact of the prefrontal with the nasal, because no nasals are preserved in MSNM BES SC 1018 (but see p. 52 for discussion).

Lacrimal

Only the left lacrimal is exposed. It is a small, elongate subtriangular element. Antero-ventrally it is received into the posterior concavity of the maxilla, and contacts the dorsal margin of its jugal process. Dorsally, it is sutured to the prefrontal, entering the anterior margin of the orbit to a very limited extent. Posteriorly, the lacrimal contacts the anterior end of the suborbital process of the jugal. A lacrimal foramen is positioned close to the contact of the lacrimal with the maxilla.

Postfrontal

Remains of the left postfrontal are probably preserved between the left parietal and supraorbital process of the postorbital (see below).

Squamosal and Postorbital

The identification of the squamosal and postorbital in MSNM BES SC 1018 is problematic.

An arched element forming the posterior margin of the orbit was identified as the left postorbital. Remnants of bone projecting posteriorly from the arch are interpreted as part of the postorbital (squamosal process). Consequently, this element appears to be triradiate. The precise extent of the antero-dorsal supraorbital process (=orbital process *sensu* Wild, 1974: fig. 2) of the postorbital cannot be determined, because this area of the skull is badly crushed. It is assumed that this area comprises remnants of the left parietal, postfrontal and postorbital (supraorbital process) but the inter-relationships of the three elements cannot be discerned and are only tentatively represented in Fig. 12. Ventrally, the postorbital forms a bipartite jugal process. Each ramus of the jugal process tapers into a blunt tip. The anterior ramus of the jugal process is in close proximity to the groove on the postorbital process of the jugal. Postero-dorsally the postorbital forms a squamosal process, that is no longer articulated with the squamosal. Based on this interpretation of the postorbital, the squamosal would not be preserved in MSNM BES SC 1018.

Alternatively, the remnants of bone assumed to be part of the postorbital (squamosal process) might represent the left squamosal, and the postorbital would be an arched rather than a triradiate element. I also considered that an unidentified element preserved dorsal to the postorbital might represent a squamosal. However, by comparison with other specimens of *Tanystropheus* and related taxa, these latter interpretations of the squamosal and postorbital appear to be less supported (see discussion on pp. 53-55).

Jugal

Both jugals were identified but the right one is concealed to a large extent, and only part of its thickened ventral margin is exposed.

The left jugal is perfectly preserved in lateral view, closely resembling in shape that described in MSNM BES SC 265. However, the jugal of MSNM BES SC 1018 provides more anatomical detail. In particular, the longitudinally elongate groove on its postorbital process is far more distinct and a crest delimits the groove posteriorly. Posterior to the crest a shallow fossa is clearly visible.

Quadrate

The isolated left quadrate, badly crushed and not complete, is situated posterior to the jugal. It is considered to be in lateral view, with a concave posterior margin and an expanded dorsal cephalic condyle. The medial lamina is partly exposed. The isolated right quadrate was tentatively identified close to the right mandibular ramus but this element is strongly distorted and does not warrant description.

Ceratobranchials

Ceratobranchial I lies in close proximity to the right lower jaw. It is very similar in shape to that described for MSNM BES SC 265.

Neurocranium

Among the bones of the neurocranium only the supraoccipital was identified. It is exposed as an isolated element in dorsal view and exhibits a distinct sagittal crest (=*crista occipitalis*, Wild, 1974: 14).

Scleral plates

Isolated scleral plates are preserved in MSNM BES SC 1018. Four, with a subrectangular shape, are positioned dorsal to the skull. Other elements, mostly with a very irregular shape and sometimes with a pitted surface, lie inside the orbit. They all apparently represent crushed and poorly preserved scleral plates. It is impossible to determine the full number of the scleral plates.

Lower jaw

Both mandibular rami are rather well preserved, the left in lateral view and the right in medial view. They are still close to each other at the mandibular symphysis.

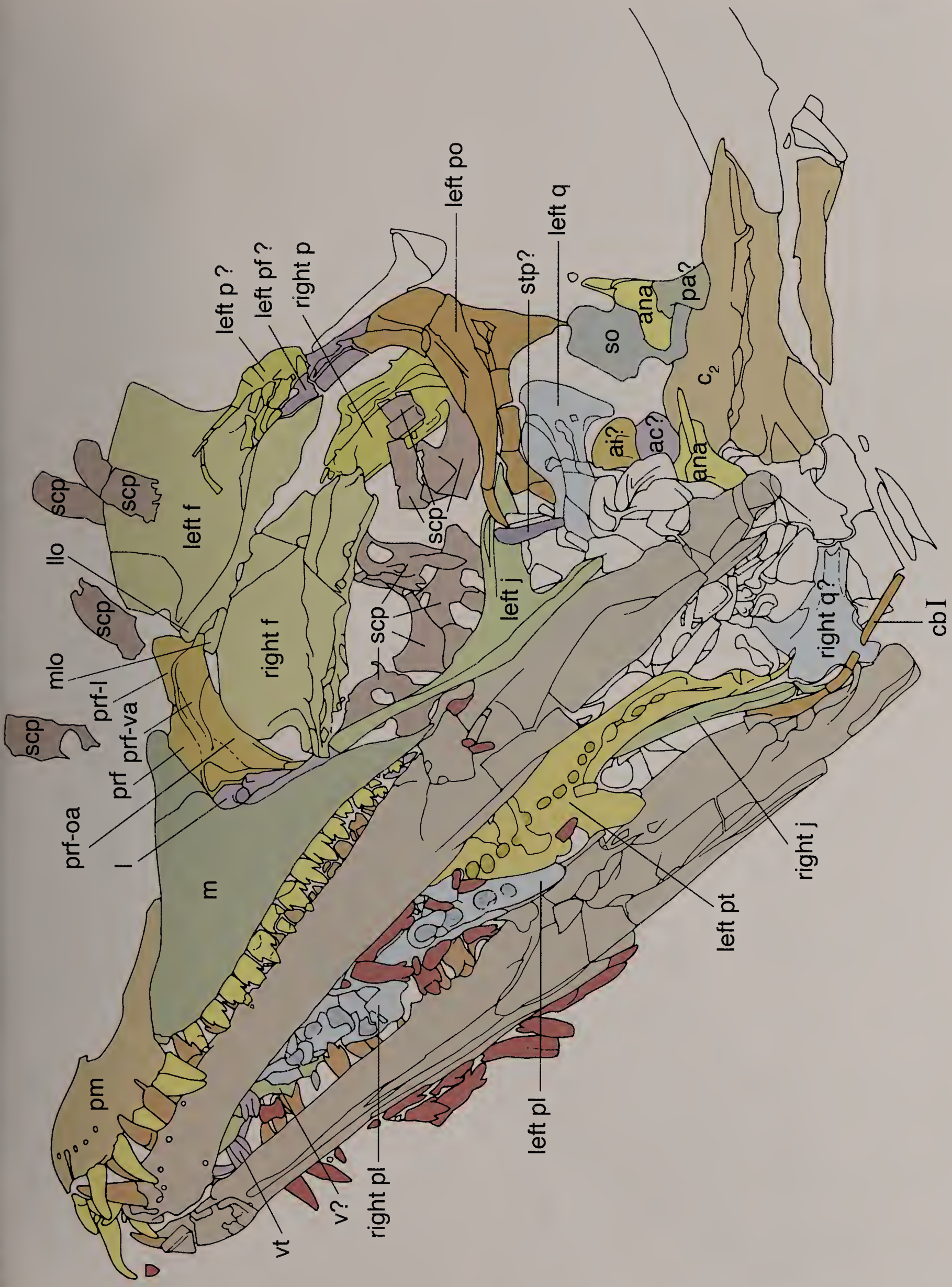

Fig. 12 – *Tanystropheus longobardicus*, MSNM BES SC 1018, skull. Red teeth: isolated maxillary or dentary teeth. The extent of the left parietal and postfrontal, and the dorsal extent of the left postorbital (supraorbital process) are arbitrarily chosen. Drawing: Massimo Demma.

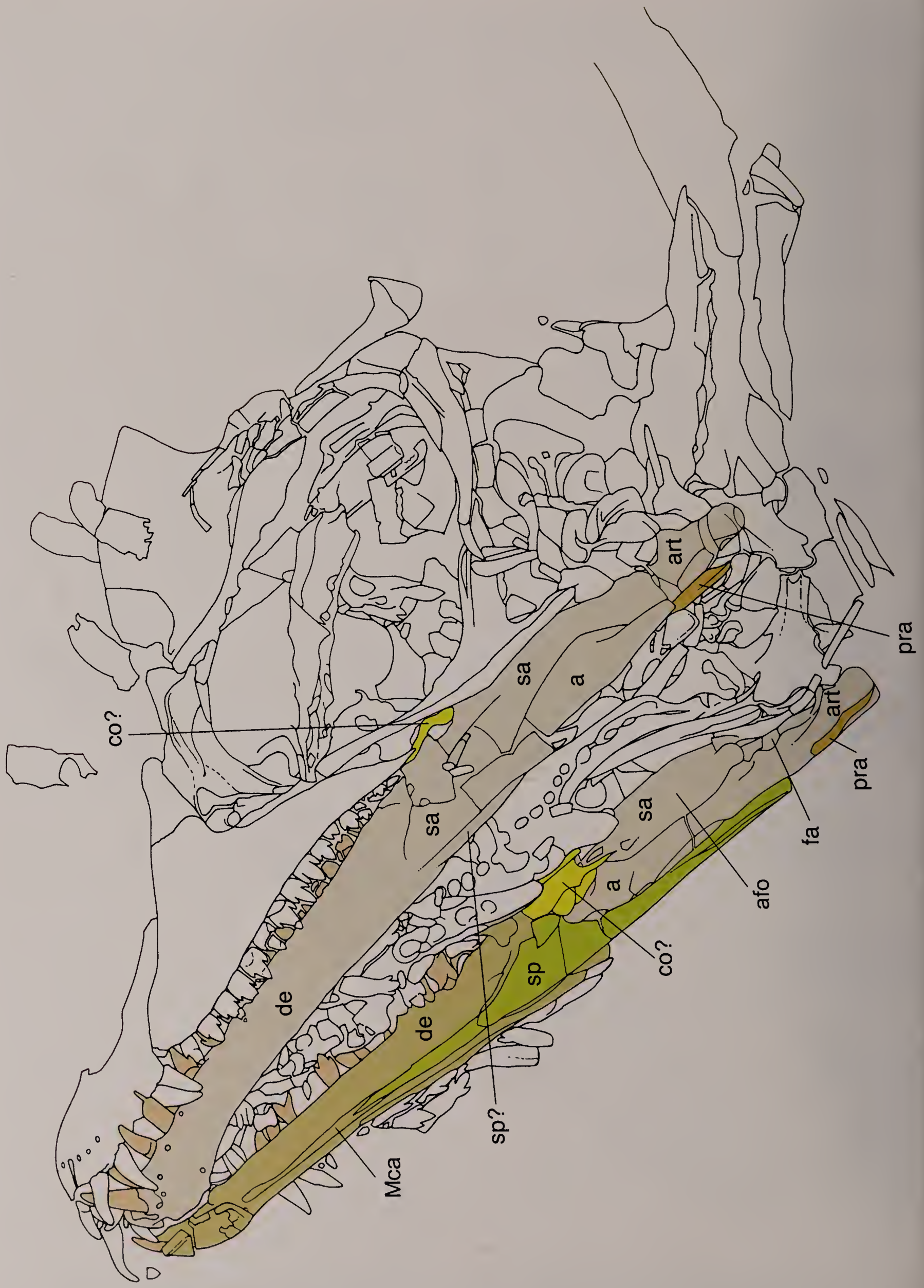

Fig. 13 – *Tanystropheus longobardicus*, MSNM BES SC 1018, lower jaws. Drawing: Massimo Demma.

In the left mandibular ramus (Figs. 13, 49 E) the dentary is complete. As previously mentioned, the anteriormost conical dentary teeth interlock with the premaxillary teeth. The first dentary tooth, preserved in the right lower jaw, cannot be seen on the left side but four subsequent teeth are distinct. One more conical tooth is almost completely concealed by the two posteriormost premaxillary teeth. Thus there was a total of six conical teeth anteriorly. The tooth immediately posterior to the sixth dentary tooth is unequivocally tricuspid, as are all the subsequent teeth. These teeth are overlapped to a large extent by the corresponding teeth of the maxilla but they can be readily counted. There are eleven tricuspid teeth preserved, and two empty tooth positions (eighth and 11th), giving a total of 13 tricuspid teeth. The dentary tricuspid teeth are not interlocking with but lingual to the maxillary tricuspid teeth. Shallow fossae delimited by bulges on the side of the dentary mark the position of each tooth alveolus. Posterior to the dentary, the left mandibular ramus is crushed and fragmented. The oblique line anteriorly delimiting the crushed posterior part of the lower jaw probably represents the suture between the dentary and the surangular (p. 59, Fig. 49). The configuration of the postdentary elements is not entirely clear in the left lower jaw. Only the prearticular can be clearly identified. It has shifted ventrally relative to the articular. A facet on the articular was for the reception of the prearticular. I also tentatively identified part of the splenial below the surangular. It is uncertain whether a coronoid was present or not (p. 61).

The right mandibular ramus is completely preserved (Figs. 13, 53 B). The Meckelian canal runs along the entire length of the dentary. The dentary teeth are mostly displaced. The splenial is a large bone forming to a large extent the ventral margin of the lower jaw. It extends far anteriorly, roofing part of the Meckelian canal, and posteriorly it underlies the angular and the articular. Between the anterior and posterior slender extensions, the splenial forms a large part of the medial side of the lower jaw. Posteriorly, the prearticular is clearly identifiable as a ribbon-shaped sheet of bone overlapping the articular ventrally. The sutures between the articular, surangular, angular and the putative coronoid cannot be determined, and I can only assume the approximate position of these elements. However, the adductor fossa bordered by these bones is perfectly preserved, as is the articular fossa for the quadrate.

Axial skeleton
(Figs. 10-12, 14-20, 54, 56 B, 59, Pls. III-IV, Tab. 2)

Cervical vertebrae and ribs (Figs. 10-12, 14, 54, 56 B, 59, Pls. III-IV, Tab. 2)

Eleven cervical vertebrae are preserved in left lateral view. Vertebrae two through nine are complete. Some parts of the atlas lie as isolated elements close to the axis. In particular, both atlas neural arches are preserved in lateral view (Figs. 10-12, 56 B). Their slightly dissimilar shape is probably due to compression. The left atlas neural arch overlaps the axis, and it is only slightly displaced relative to the axis prezygapophysis. The right neural arch is an isolated element preserved close to the axis. It is clearly sutured to another element that is tentatively interpreted as the proatlas. Two polygonal, articulated elements preserved dorsal to the left neural arch of the atlas (Figs. 10-12) might be the atlas centrum and intercentrum but this interpretation remains very doubtful. The tenth vertebra is incomplete, lacking its posterior half. However, the postzygapophysis of the tenth cervical is still preserved in articular contact with the prezygapophysis of the 11th (Fig. 14). The 11th cervical is completely preserved as an isolated element. Partial collapsing of the bony walls into the hollow vertebral centra (Wild, 1974: 81) is apparent in the cervical series.

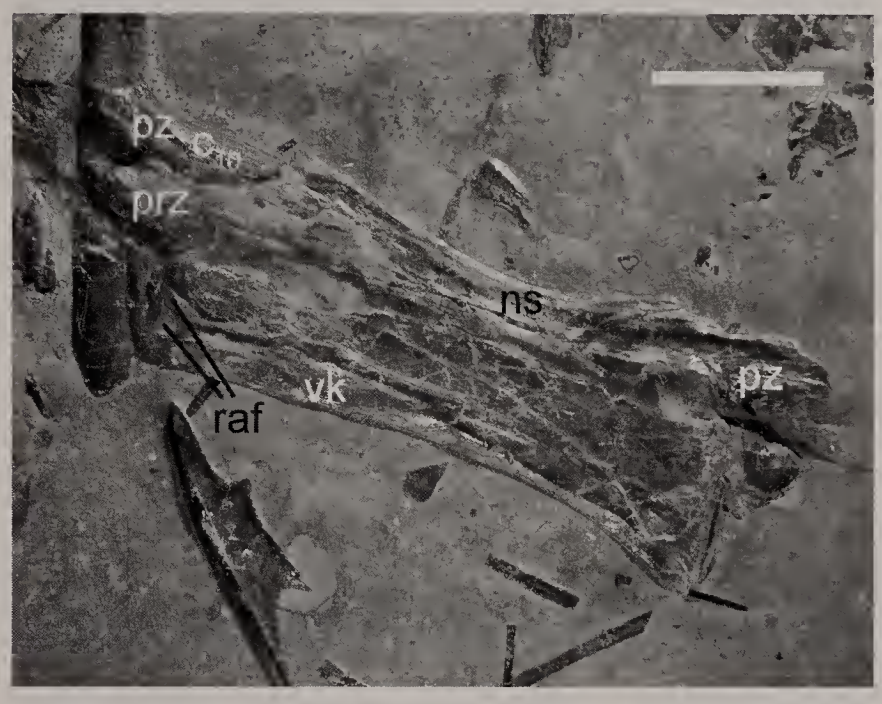

Fig. 14 – *Tanystropheus longobardicus*, MSNM BES SC 1018, eleventh cervical vertebra in left lateral view. Pz c_{10}: postzygapophysis of the tenth cervical vertebra. Scale bar 10 mm. Photo: Massimo Demma.

Cervicals two through ten form an articulated series, with the exception of the fourth and fifth (Fig. 59). Although the cervical vertebral column of MSNM BES SC 1018 is no longer articulated with the dorsal vertebral column - the elements of which are mostly isolated scattered elements - it is clearly tilted backwards, as commonly observed in other *Tanystropheus* specimens. Although the cervical series is not properly articulated with the skull, it maintains its approximate original position relative to it.

Because of compression it is impossible to take reliable measurements of the vertebrae, apart from their length (Tab. 2).

The third through tenth pairs of cervical ribs are preserved in close proximity to the corresponding centra, sometimes still in articulation. Their shafts are extensively broken. Three anteriormost shorter elements displaced ventral to the axis were identified as the ribs of the first two cervical vertebrae. Other rib heads and fragments of their shafts are scattered on the slab.

Dorsal vertebrae and ribs (Figs. 15-18, 20, Pls. III-IV)

Thirteen dorsal vertebrae are preserved. Five of them, identified as five through nine or six through ten, form a partially articulated series still approximately positioned in the trunk region (Pls. III-IV, Figs. 15, 20). They are exposed in left lateral view. Three additional isolated

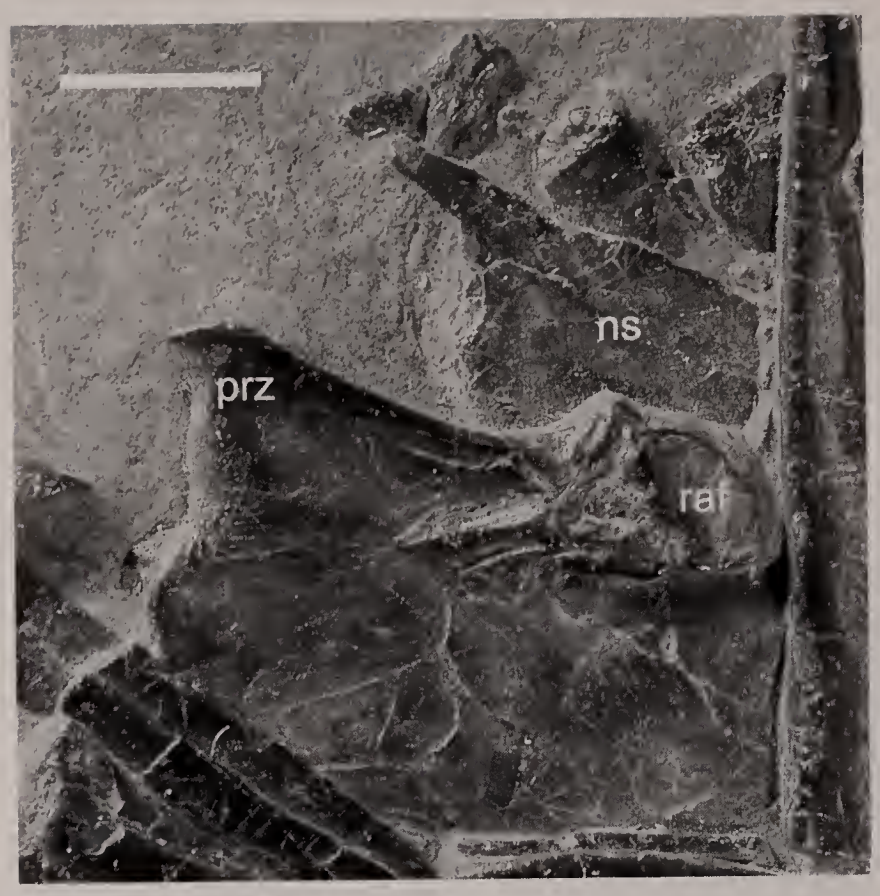

Fig. 15 – *Tanystropheus longobardicus*, MSNM BES SC 1018, mid-dorsal vertebra (see discussion on p. 68) in left lateral view. Scale bar 5 mm. Photo: Massimo Demma.

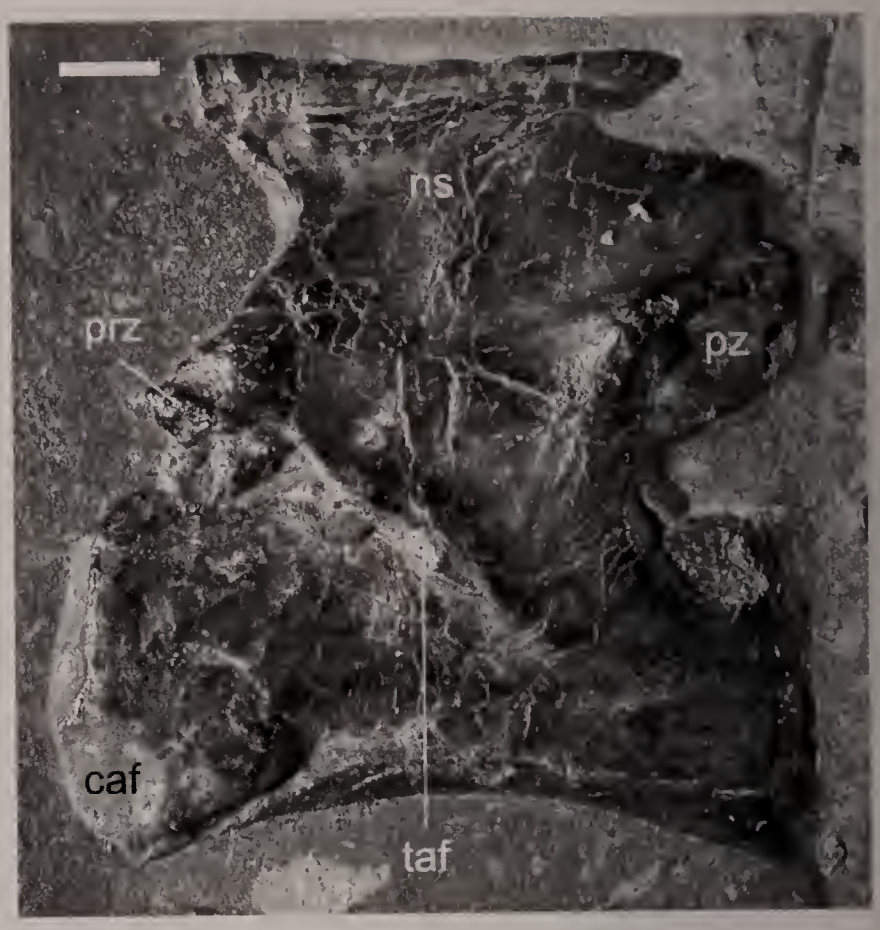

Fig. 16 – *Tanystropheus longobardicus*, MSNM BES SC 1018, anteriormost dorsal vertebra (see discussion on pp. 67-68) in left lateral view. Scale bar 10 mm. Photo: Massimo Demma.

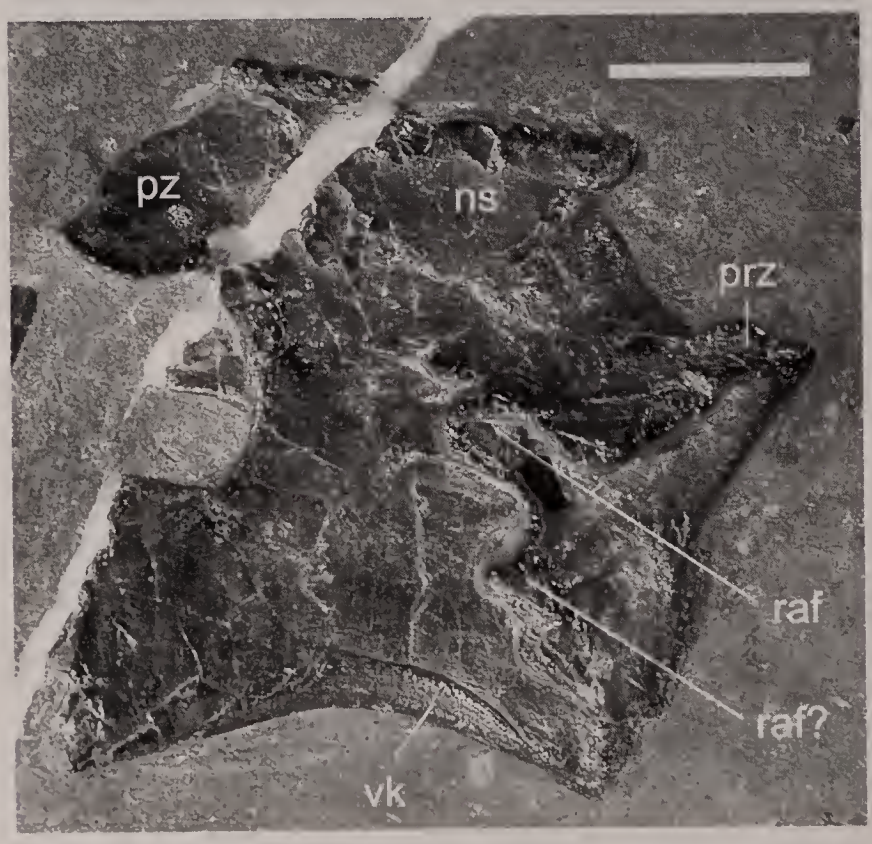

Fig. 17 – *Tanystropheus longobardicus*, MSNM BES SC 1018, presumed fourth dorsal vertebra (see discussion on p. 69) in right lateral view. Scale bar 5 mm. Photo: Massimo Demma.

Fig. 18 – *Tanystropheus longobardicus*, MSNM BES SC 1018, presumed eleventh dorsal vertebra (see discussion on p. 69) in right lateral view. Scale bar 5 mm. Photo: Massimo Demma.

dorsal vertebrae are tentatively interpreted as one of the first three anteriormost dorsal, the fourth, and the 11th. The anteriormost dorsal (Fig. 16) is exposed in left lateral view: its centrum is 14.8 mm long. Both pre- and postzygapophyses and the posterior end of the neural spine are broken. The putative fourth dorsal (Fig. 17) is exposed in right lateral view: its centrum is 15.4 mm long. A fracture crosses the posterior area of the neural arch and continues along the border of the posterior end of the centrum. The putative 11th dorsal (Fig. 18) is exposed in right lateral view: its centrum is 14.6 mm long.

The preserved, disarticulated dorsal ribs mostly cluster in the trunk region. They are stout, longitudinally grooved elements. All of them are holocephalous. A single, short dichocephalous rib is preserved close to the isolated right femur (Pls. III-IV). It was clearly associated with one of the anteriormost dorsals.

Fig. 19 – *Tanystropheus longobardicus*, MSNM BES SC 1018, sacral vertebra in right lateral view. Scale bar 5 mm. Photo: Massimo Demma.

Sacral vertebrae (Fig. 19)

One sacral vertebra is preserved as an isolated element exposed in right lateral view. It bears a stout, albeit crushed, pleurapophysis (*sensu* Wild, 1974; see note on p. 69). The centrum is slender and the low neural spine raises posteriorly into a rounded process.The amphicoelous centrum of this vertebra is 14 mm long.

Caudal vertebrae (Pls. III-IV)

Twelve caudal vertebrae are scattered on the slab.

A group of six caudal vertebrae exposed in lateral or ventro-lateral view is preserved in the same area as the scattered elements of the right hindlimb. When measurable, the centrum length of these vertebrae is approximately 12 mm, although the caudal to the left of the anteriormost preserved dorsal (Pl. IV, $d_{1\text{-}3}$?) has a centrum length of 16.4 mm. The centrum is amphicoelous. The shape of these vertebrae is difficult to interpret but the presence of pleurapophyses (*sensu* Wild, 1974; see note on p. 69), sometimes very wide at the base, indicates that they are most likely proximal caudals.

An additional proximal caudal vertebra is preserved in antero-lateral view close to the distal part of the right tibia. The right pleurapophysis is distally truncated and a line at the very base of it might be interpreted as a suture (see note on p. 69). The orientation of the prezygapophyseal articular facets is sub-horizontal. Ventral to the amphicoelous centrum, the chevron is preserved. It is a Y-shaped element and the two rami are proximally connected by a transverse bony bar.

Three more caudal vertebrae lie in the area between the cervical vertebral column and the left femur. Two of them lie to the right of the first articulated series of distal caudal vertebrae. They are very deformed and their shape is difficult to interpret. One of the two appears to preserve pleurapophyses and on this basis it might be assumed to be part of the proximal caudal vertebral column. A third caudal lies to the right of cervical ten, and is preserved in left lateral view. The centrum is 16.9 mm long. By direct comparison with MSNM BES SC 265, this vertebra is tentatively identified as the ninth caudal. A pleurapophysis is lacking but a shallow, yet distinct tiny fossa is present on its lateral surface. This small fossa is seen in other isolated caudals of MSNM BES SC 1018 ventral to the pleurapophyses.

Finally, two vertebrae preserved in anterior view are identified as distal caudal vertebrae. They are very small and lack pleurapophyses. One is close to the mid-dorsal series in the trunk region. The second is partially overlapped by the proximal part of the right tibia and fibula. Its centrum is weakly amphicoelous; only the pedicel of the neural arch is preserved.

Like MSNM BES SC 265, the distal caudals form two articulated series in which the centra are the only preserved vertebral elements. The articulation between the centra, however, is hardly identifiable. The first series is 5 cm long and is very poorly preserved. The second is 20 cm long and better preserved. Remnants of bone proximal to the first series probably represent other distal caudal vertebrae but they are exceptionally poorly preserved.

Gastralia

The gastralia are preserved in their original position, ventral to the trunk. They are closely packed, and, in spite of disarticulation of the different elements, they clearly form a "skeletal unit". The anterior elements are preserved in ventral view, while the posterior ones appear to be in anterior view. It is estimated that the gastral skeleton includes about 30 units, each composed by four elements.

Appendicular skeleton
(Figs. 20-29, 62, Pls. III-IV, Tabs. 5-6, 8-9)

Specimen MSNM BES SC 1018 is unique amongst all known specimens of *Tanystropheus* with respect to the beautiful preservation of the limbs. By contrast, the preserved elements of the pectoral and the pelvic girdles are displaced, and some of them are fragmentary or broken.

Pectoral girdle (Fig. 20)

All the elements of the pectoral girdle, with the possible exception of the interclavicle, can be identified.

The left scapula is complete, and exposed in lateral view. The thick ventral peduncle bears the articular facet contributing to the glenoid cavity. Dorsal to the peduncle, the scapular blade is strongly expanded and fan-shaped, projecting more posteriorly than anteriorly. It exhibits concentric striation. The right scapula is badly broken but its overall shape is still recognizable. It is preserved in medial view.

The two coracoids lie side by side, concealed partly by the left humerus. They are plate-shaped elements. Their glenoid area is not exposed. The element to the left is probably the left coracoid in ventral view, and the one to the right is the right coracoid in dorsal view.

The two clavicles are preserved in between the scapulae. The element overlapping the left scapula is most likely the left clavicle in ventral view, while the other is the right clavicle in anterior or posterior view (Wild, 1974: 103, figs. 65, 91).

An element overlapped by the right clavicle is tentatively interpreted as the interclavicle. Two distinct processes which embrace the clavicles project laterally from the anterior plate. This presumed interclavicle has a shape different from the only other interclavicle reported in the material of *Tanystropheus* (Wild, 1974: 103, fig. 64).

Fig. 20 – *Tanystropheus longobardicus*, MSNM BES SC 1018, pectoral girdle and mid-dorsal vertebra in left lateral view. Scale bar 15 mm. Photo: Massimo Demma.

Forelimb (Figs. 21-23, Tabs. 6, 8-9)

Both forelimbs are superbly preserved in complete articulation. They are without doubt the best preserved forelimbs of all known *Tanystropheus longobardicus* specimens.

The right humerus (Fig. 21) is exposed in anterior view. Because of the twisting of the two articular ends relative to each other (Wild, 1974: 106, fig. 67), the expansion of the proximal end and the profile of the distal end are evident. Although the distal end is crushed, the rounded shape of the two condyles is clear. The forearm is preserved in anterior view, and the manus in dorsal view. The radiale and the lateral distal carpal are each broken into two pieces.

The left forelimb (Fig. 22) is stretched, the humerus, exposed in ventral view, lying along the same longitudinal axis as the forearm, exposed in anterior view. The manus is exposed in dorsal view. Because of compression, the proximal end of the humerus lies on the same plane as the distal one. A crack crosses the proximal end of the humerus but all other elements are intact. A sesamoid bone is preserved in the elbow joint.

The humeri have a more or less straight shaft and expanded ends. The proximal end is slightly convex, the distal one is differentiated into two condyles.

The epipodials are of sub-equal length, and have approximately equally expanded ends. In anterior view, the proximal end of the radius slightly overlaps that of the ulna, and vice versa distally. The radius is stouter than the ulna. Its ulnar margin is concave. Both ends are slightly expanded and have flat articular surfaces. The ulna is a slender element with concave margins and expandend ends, the proximal slightly more so than the distal one. The articular surfaces are distinctly convex, particularly the distal one. A spatium interosseum is present.

The carpus includes four ossified elements (Fig. 23). The proximal two, the radiale and the ulnare, meet each other along a straight line and enclose a well-defined perforating foramen. Following Wild (1974), the two distal carpal elements are referred to as the medial and the lateral one, because their homology is at present unknown. Contra Wild (1974: 109, fig. 70), the largest distal carpal is the lateral one. It is a roundish element positioned between the ulnare, proximally, and the proximal heads of metacarpals III and IV, distally. Medially, the lateral distal carpal contacts a rounded medial distal carpal. The latter is in juxtaposition with the proximal heads of metacarpals II and III. There is a wide gap between the medial distal carpal and the radiale, and the medial region of the carpus is unossified.

Fig. 21 – *Tanystropheus longobardicus*, MSNM BES SC 1018, right forelimb. Scale bar 20 mm. Photo: Luciano Spezia.

Fig. 22 – *Tanystropheus longobardicus*, MSNM BES SC 1018, left forelimb. Scale bar 20 mm. Photo: Luciano Spezia.

Fig. 23 – *Tanystropheus longobardicus*, MSNM BES SC 1018, left manus in dorsal view. Broken lines indicate the contours of the caudal vertebra which was erased to highligth the carpus. I-V = metacarpals. Scale bar 5 mm. Photo: Massimo Demma.

Table 6 – *Tanystropheus longobardicus*, measurements of the forelimbs in MSNM BES SC 1018 (* = estimated; n. m. = not measurable).

	Length (mm)	
	right	left
Humerus	n. m.	67.5
Radius	44.6	44.9
Ulna	43.8	44.1
Metacarpal I	7.3	7.6
Metacarpal II	13.0	13.0
Metacarpal III	14.2	14.0
Metacarpal IV	13.4	13.3
Metacarpal V	6.6	6.6
	Digit I	
Phalanx 1	5.1	5.4
Ungual	4.0	4.3
	Digit II	
Phalanx 1	5.6	5.8
Phalanx 2	4.2	4.0*
Ungual	4.5	4.0*
	Digit III	
Phalanx 1	6.6	6.9
Phalanx 2	4.3	4.3
Phalanx 3	3.9	3.8
Ungual	3.9	4.0
	Digit IV	
Phalanx 1	6.2	6.6
Phalanx 2	4.2	4.5
Phalanx 3	3.9	3.8
Ungual	3.7	3.9
	Digit V	
Phalanx 1	5.7	5.7
Phalanx 2	4.6	4.6
Ungual	3.7	3.7

Metacarpals I and V are far shorter than the others, with V being the shortest. Metacarpals II through IV are distinctly longer. Metacarpal III is the longest, followed by IV and then II. The proximal ends of metacarpals II through IV overlap. In dorsal view each medial element overlaps the lateral one. The phalanges do not look as thick and shortened as in Wild's reconstruction (1974: fig. 70). The phalangeal formula of the manus is 2,3,4,4,3 (see Tab. 9 for comparison with other protorosaurian taxa).

Measurements of the elements of the forelimbs in MSNM BES SC 1018 are given in Tab. 6. Length ratios between different elements of the forelimbs are given in Tab. 8.

Pelvic girdle (Figs. 24-25, Pls. III-IV)

The left elements of the pelvic girdle (Fig. 24) are better preserved than the right ones, albeit fragmentary. The ilium, ischium and pubis approximately maintain their position relative to one another but have separated. They are exposed in lateral view. Fragments of the right elements of the pelvis are scattered in the same area.

The left ilium has a posteriorly projecting dorsal blade and a wide, ventral acetabular portion. The ilium contributes most to the acetabulum. A distinct waist separates the two parts. The dorsal blade tapers posteriorly into a blunt process. Anteriorly, it is concealed to a large extent by a fragment of the supposed right pubis but it is clearly far shorter than posteriorly. A short pre-acetabular proc-

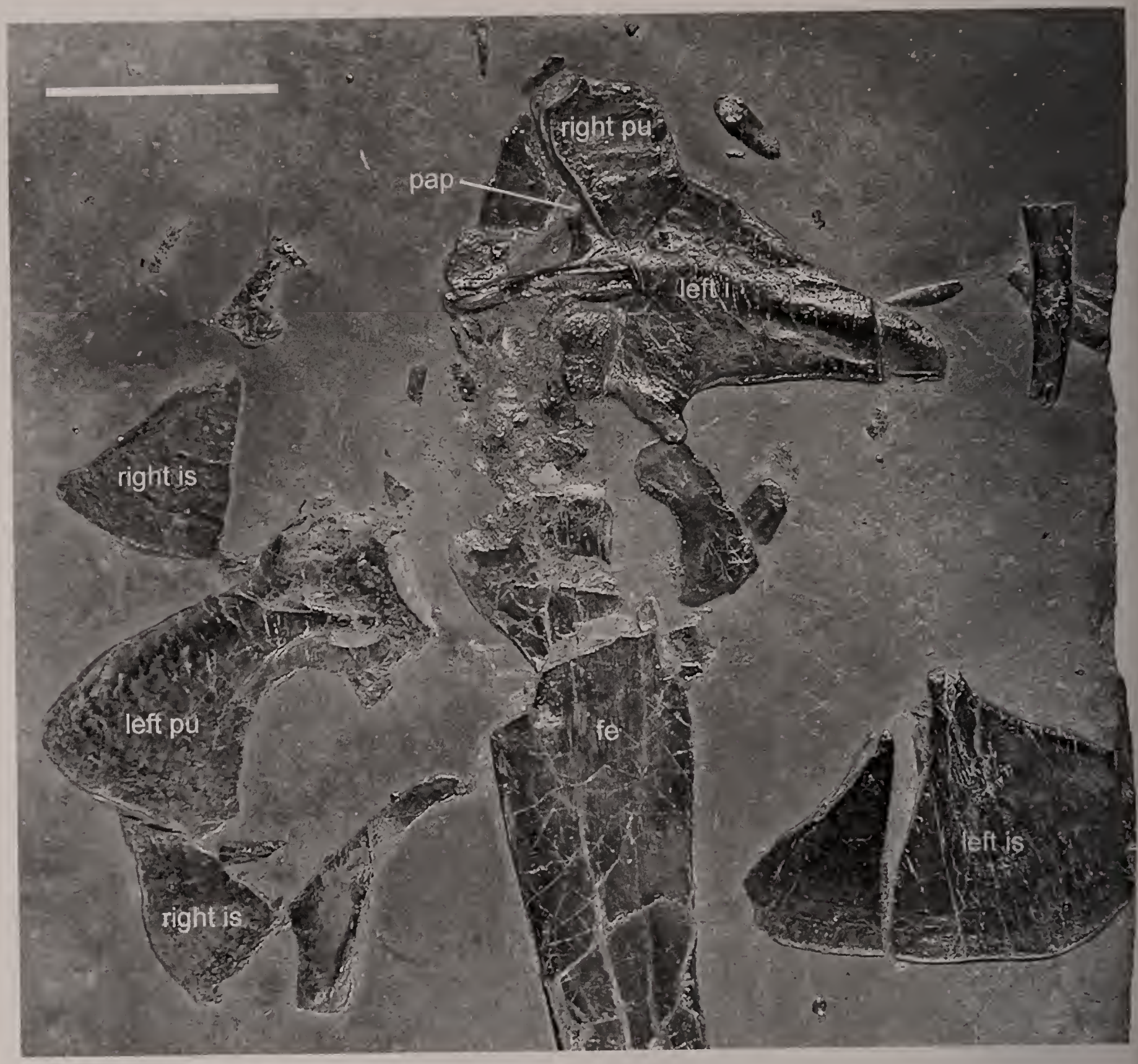

Fig. 24 – *Tanystropheus longobardicus*, MSNM BES SC 1018, pelvic girdle. Scale bar 15 mm. Photo: Massimo Demma.

ess or tubercle is present anteriorly. The posterior part of the dorsal blade deepens into a fossa, dorsally sulcated by a groove. The acetabular fossa is dorsally framed by the acetabular buttress. Its ventral margin is not identifiable but posterior to it the articular facet for the ischium is distinct. The right ilium (Pls. III-IV) is displaced close to the 11th cervical vertebra, and is exposed in lateral view. Only its post-acetabular portion is preserved. The iliac blade has the same shape as the left side.

The left pubis is complete. It is differentiated into an acetabular part and a ventral blade. The latter is antero-posteriorly expanded and its surface exhibits concentric striation. In the acetabular region, a distinct articular peduncle for the ischium projects posteriorly. Consequently, the posterior margin of the pubis, bordering the thyroid fenestra, is strongly concave. A wide, oval obturator foramen pierces the pubis in this area. Anterior to the peduncle, the acetabular facet of the pubis is distinct. Anterior to the acetabular facet, the margin of the pubis is damaged. In this area it contacted the pre-acetabular part of the ilium and apparently formed a pubic tuberosity. Contra Wild (1974: 112, fig. 71), a *processus lateralis* similar to that observed in the extant squamates was not identified in the pubis of MSNM BES SC 1018. Dorsally, the anterior margin of the pubis is straight, ventrally, is very slightly convex. A fragment of bone overlapping the anterior part of the iliac blade is tentatively interpreted as the proximal part of the right pubis.

Only the fan-shaped, ventralmost part of the left ischium is preserved, broken in two pieces. Fragments of the same region of the right ischium are preserved close to the left pubis. The surface of the ischiadic blades displays concentric striation.

The left side of the pelvic girdle of MSNM BES SC 1018 is reconstructed in Fig. 25.

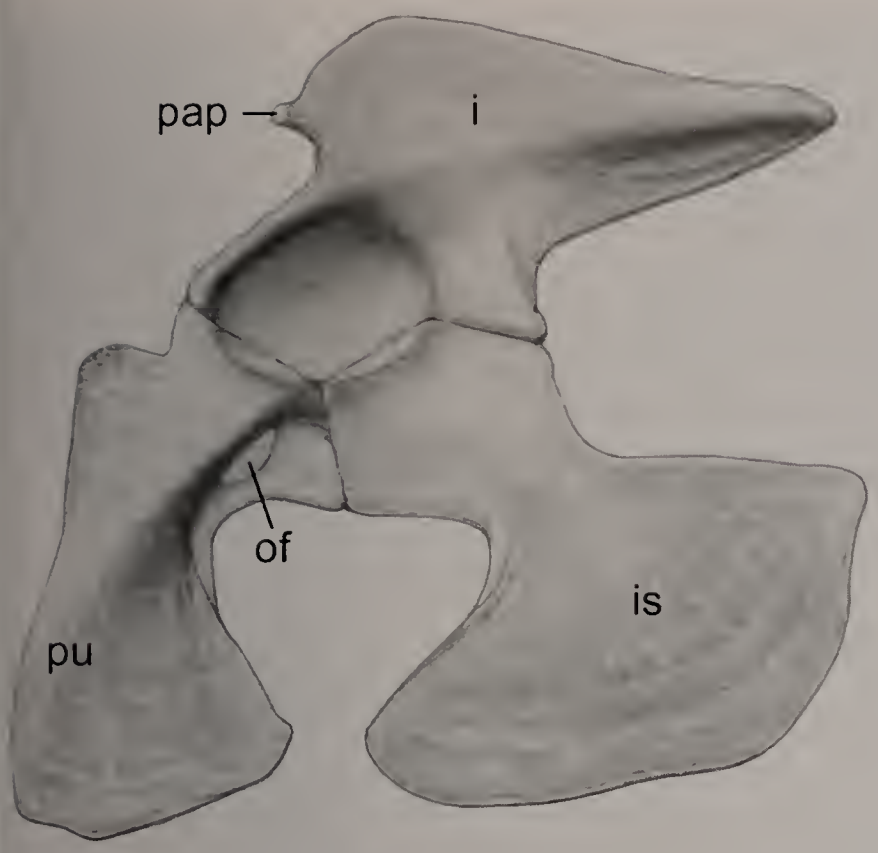

Fig. 25 – *Tanystropheus longobardicus*, reconstruction of the pelvic girdle (left side in lateral view) based on MSNM BES SC 1018. Watercolor: Massimo Demma.

Hindlimb (Figs. 26-29, Pls. III-IV, Tabs. 5, 8-9)

The preserved elements of the right hindlimb (Fig. 26, Pls. III-IV) are disarticulated and scattered. The right femur is preserved in antero-dorsal view. The shaft is proximally broken, at approximately four fifths of the length of the bone. Another piece lies to the right of this larger piece. The isolated proximal end of the femur (Fig. 26) lies ventral to the trunk. The articular surface is convex. The distal end is deflected ventrally, giving the shaft a gently curved shape. The tibial condyle widely conceals that for the fibula. The rounded shape of the condyles suggests that they formed sub-cylindrical articular surfaces for the tibia. The right tibia is broken into two pieces. One represents approximately two thirds of the overall length of the bone and includes the proximal end. It is displaced to a position dorsal to the trunk, and is exposed probably in dorsal view. The crushed distal end with the distalmost part of the shaft is preserved on the other side of the trunk. Both ends of the tibia are expanded. The proximal end of the right fibula with the proximalmost part of its shaft is still articulated with the tibia. The larger part of the shaft with its distal end lies close to the femoral head. Disarticulated elements of the right pes are preserved in the same area as the femoral shaft. Distal tarsal three and distal tarsal four together with metatarsals I through IV lie close to one another, and there are some scattered phalanges. The astragalus and calcaneum are the only articulated elements of the right pes. The astragalus and calcaneum unit is exposed in plantar-distal view. The medial swollen part of the astragalus was crushed on its lateral part, exposing its distal surface. Consequently, the astragalus is strongly deformed.

Fig. 26 – *Tanystropheus longobardicus*, MSNM BES SC 1018, proximal end of the right femur. Scale bar 5 mm. Photo: Massimo Demma.

All the elements of the left hindlimb (Fig. 27) are preserved to the right side of the neck. Although not properly articulated, the femur, crus, and pes are preserved close to one another in their original proximo-distal sequence. The left femur is exposed in antero-dorsal view. Its proximal head is broken into small pieces but it is still clearly facing the acetabular part of the left ilium. The shaft is gently, sigmoidally curved. The two rounded distal condyles are exposed, the tibial widely concealing that for the fibula (Fig. 29). The tibia and the fibula rotated slightly clockwise on their longitudinal axis and fell as a unit. The two bones lie thus parallel to each other and are probably exposed in antero-medial view. In this view, the proximal end of the tibia is more expanded than the distal one. The medial margin of its shaft is slightly concave. The fibula is a slender bone with a sigmoidal shape and no expanded ends. The tibia and the fibula are equal in length. The pes (Fig. 28) is exposed in plantar view. All the elements of the tarsus are preserved (Fig. 62) but the articulated astragalus and calcaneum unit was displaced and turned upside down, so exposing its dorsal side. The astragalus and calcaneum meet along a straight line and enclose a well-defined foramen for the perforating artery (Wild, 1974: 116). The articular facet for the fibula formed by the two bones is exposed on the proximal side of the astragalus and calcaneum unit. On the distal side, both astragalus and calcaneum contribute to a fossa, proximally delimited by a sharp margin. The medial part of the astragalus is partly overlapped by metatarsal V. Distal tarsal three and distal tarsal four contact metatarsals III and IV respectively but distal tarsal four does not meet the proximal end of metatarsal V. Therefore some dislocation probably occurred. The metatarsals and the phalanges are completely preserved in articulation. The proximal ends of the metatarsals overlap, each lateral element overlapping the medial one. A small but clearly delimited ventral tubercle is seen close to the lateral margin of metatarsal V. The phalangeal formula of the pes is 2,3,4,5,4 (see Tab. 9 for a comparison with other protorosaurian taxa).

Measurements of the elements of the left hindlimb in MSNM BES SC 1018 are given in Tab. 5. Length ratios between different elements of the hindlimbs are given in Tab. 8.

Fig. 27 – *Tanystropheus longobardicus*, MSNM BES SC 1018, left hindlimb. Scale bar 30 mm. Photo: Luciano Spezia.

Fig. 28 – *Tanystropheus longobardicus*, MSNM BES SC 1018, left pes in plantar view. Astragalus and calcaneum in dorsal view. I-V = metatarsals. Scale bar 10 mm. Photo: Roberto Appiani.

Fig. 29 – *Tanystropheus longobardicus*, MSNM BES SC 1018, left hindlimb, knee joint. Scale bar 10 mm. Photo: Massimo Demma.

Specimen MSNM V 3663 a b
(Figs. 30-32)

Specimen MSNM V 3663 is a skull with five associated cervical vertebrae preserved on a part (V 3663 a), and a natural mould with remains of bone and teeth on a counterpart plate (V 3663 b). It is notable for its large size and the preservation of some elements of the temporal region and of the vomerine dentition.

By comparison with the skulls of MSNM BES SC 265 and MSNM BES SC 1018, the overall length of the individual represented by this specimen is estimated to have been at least 3 m. In addition, the length of the most complete cervical vertebra in MSNM V 3663, representing an element of the series six through nine, is 17 cm. This length corresponds to that of the cervical vertebrae six-seven in specimens estimated to be approximately 3.5 m long (PIMUZ T 2790 and PIMUZ T 2819) in the PIMUZ Collections (Wild, 1974: tab. 3).

The length of the skull, measured from the posteriormost extent of the parietals (as preserved) to the anteriormost extent of the right lower jaw, is 12 cm. The skull is exposed in ventral view and very poorly preserved. It is heavily crushed and the surface of the bone is worn away. Few elements of the skull could be identified. In the preorbital region there is a small part of the premaxilla with conical premaxillary teeth, part of the right maxilla with conical maxillary teeth, and the vomers. The latter exhibit a series of tooth alveoli: seven on the right vomer and five on the left. Teeth are present in some of these. These teeth are very small and apparently conical but their tips are broken. The anteriormost of the preserved teeth on the left vomer has a basal diameter of 1.3 mm.

Some elements of the skull roof, circumorbital series and of the temporal region are also exposed. Remains of the parietals and frontals can be discerned but they are indistinct. By contrast, the right postfrontal, still articulated to the fronto-parietal plate, can be clearly identified. It is articulated with another element which is interpreted as a fragmentary postorbital. Finally, the right jugal is exposed in medial view. Posterior to the elements described, a partial natural mould and remains of bone probably represent the squamosal, and indicate the posteriormost extent of the skull.

The anteriormost part of the right dentary, exposed in lateral view, overlaps the premaxilla. Another fragment of the right lower jaw is preserved just anterior to the right jugal. The fragmented, anteriormost part of the left dentary and a partial natural mould of the left lower jaw are seen on the left side of the skull.

On the counterpart plate, a partial natural mould of the right lower jaw and remains of it can be identified. Moulds and remains of the premaxillary and maxillary teeth are distinct as well.

The preserved cervical vertebrae are crushed and fragmented and their morphology cannot be described in detail. It can be only stated that they have the typical elongate shape of cervicals three through ten. One pair of fragmentary, originally articulated vertebrae is preserved close to the skull. Another segment of the cervical vertebral column is represented by three, originally articulated elements: the posterior end of one vertebra, a second more complete vertebra and the anteriormost part of a third. Fragments of cervical ribs run ventral to the vertebrae.

Specimen MSNM BES 215
(Fig. 33)

Specimen MSNM BES 215 is an isolated mid-dorsal vertebra in posterior view (p. 68). It is significant for its large size and the peculiar morphology. Although embedded in a slab, the vertebra is fairly three-dimensionally preserved.

The vertebra lacks the dorsal part of the neural spine. Its height, measured from the ventral surface of the centrum to the maximum dorsal extent of the broken neural spine, is 7.4 cm. The height of the centrum is approximately 3 cm. By comparison with the height of the centrum of the mid-dorsal vertebrae of MSNM BES SC 1018 and the large *T. conspicuus* (Wild, 1974: fig. 54), the overall size of the individual to which MSNM BES 215 belonged is estimated to have been at least 5 m.

The centrum has an elliptic dorso-ventrally elongate shape. Its articular surface is worn away but a thickened

Fig. 30 – *Tanystropheus longobardicus*, MSNM V 3663 a, plate. Scale bar 100 mm. Preparation: Fabio Fogliazza. Photo: Luciano Spezia.

margin and a shallow central fossa are identifiable. Short and stocky transverse processes project laterally from the area between the centrum and the very base of the neural arch. The neural canal is pear-shaped and filled with matrix. Above the canal there are short postzygapophyses with flat articular surfaces that slightly slant in a dorso-lateral/medio-ventral plane. These wide articular surfaces reach the area just above the neural canal. A short bony shelf develops above the neural canal, and forms the floor of a very shallow postzygapophyseal trough (*sensu* Rieppel, 2001), within which paired postzygapophyseal canals (*sensu* Rieppel, 2001: figs. 2-3) can be seen, albeit filled with matrix. This latter feature is interesting because postzygapophyseal canals were never previously described in the post-cervical vertebrae of *Tanystropheus* (p. 68). For this reason MSNM BES 215 is here considered as *Tanystropheus* cf. *longobardicus,* albeit on the basis of its stratigraphical position it could be ascribed to *T. longobardicus*.

The neural spine of MSNM BES 215 is broken dorsally. A median longitudinal ridge runs along it, and diverges ventrally above the neural canal and between the flat articular surfaces of the postzygapophyses, framing the postzygapophyseal canals medially. The dorsal ligament would have been inserted on this ridge (Wild, 1974: fig. 38 e).

Fig. 31 – *Tanystropheus longobardicus*, MSNM V 3663 a, plate, skull. Scale bar 20 mm. Photo: Roberto Appiani. Drawing: Massimo Demma.

Fig. 32 – *Tanystropheus longobardicus*, MSNM V 3663 b, counterplate. Scale bar 10 mm. Photo: Luciano Spezia.

Fig. 33 – *Tanystropheus* cf. *longobardicus*, MSNM BES 215, mid-dorsal vertebra in posterior view. Scale bar 10 mm. Photo: Luciano Spezia.

Specimen MSNM BES 351
(Fig. 34)

Specimen MSNM BES 351 comprises isolated fragments of the shafts of cervical ribs belonging to an individual larger in size than MSNM BES SC 265 and MSNM BES SC 1018. This can be inferred from the diameter of the shafts which is approximately 2 mm in MSNM BES 351, and 0.5-1.0 mm in MSNM BES SC 265 and MSNM BES SC 1018. The diameters of the cervical ribs in specimen PIMUZ T 2819 (estimated overall

Table 7 – *Tanystropheus* cf. *longobardicus*, measurements of MSNM V 3730.

	Length (mm)
Metatarsal I	28.0
Metatarsal II	36.0
Metatarsal III	38.0
Metatarsal IV	37.8
Metatarsal V	12.2
Digit I	
Phalanx I	12.8
Ungual	6.4
Digit II	
Phalanx I	14.3
Phalanx II	8.8
Ungual	6.4
Digit III	
Phalanx I	22.6
Phalanx II	16.9
Phalanx III	9.1
Ungual	6.2
Digit IV	
Phalanx I	20.6
Phalanx II	10.0
Phalanx III	6.2
Phalanx IV	4.0
Ungual	4.0
Digit V	
Phalanx I	38.4
Phalanx II	12.7
Phalanx III	4.9
Ungual	4.4

Fig. 34 – *Tanystropheus longobardicus*, MSNM BES 351, fragments of cervical ribs. Scale bar 30 mm. Photo: Luciano Spezia.

length 3.65 m, Wild, 1974: tab. 1) are 1.0-2.0 mm proximally and thickening to a maximum between 2.0 and 3.0 mm (Wild, 1974: 60, tab. 4).

Specimen MSNM V 3730
(Figs. 35, 61, Tab. 7)

Specimen MSNM V 3730 is an isolated pes with all the elements preserved, and mostly in articulation. A partial natural mould and remains of the disarticulated epipodials are also present but are poorly preserved and provide no information on their detailed morphology. On the basis of the phalanges, which bear longitudinal grooves along their shafts and prominent distal condyles separated by a groove, this specimen most probably represents a right pes in plantar view. By comparison with MSNM BES SC 1018, the overall size of the individual to which the pes belonged is estimated to have been approximately 1.50 m.

The tarsus of MSNM V 3730 is unique for all known *Tanystropheus* material in preserving all the elements in their original position and articulation. The calcaneum is a polygonal element with roundish and thickened lateral margin. Its concave distal margin matches the rounded proximal head of metatarsal V. The astragalus is a proximo-distally elongate element, obliquely oriented within the tarsus. Its proximal end meets the calcaneum in a straight line. Half way along it there is an elongate foramen for the passage of the perforating artery (Wild, 1974: 116). Distally, the astragalus expands into a rounded head, that does not contact metatarsal II. The distal ossifications of the tarsus are roundish elements, and distal tarsal three is far smaller than distal tarsal four. Distal tarsal three lies medial to the distal head of the astragalus and is in close juxtaposition with the proximal end of metatarsal III. Distal tarsal four lies in the lateral embayment of the astragalus and contacts the proximal head of metatarsal IV distally. It contacts distal tarsal three medially and articulates with the proximal rounded head of metatarsal V laterally.

The metatarsals are tightly packed, and their proximal ends overlap. On the proximal end of metatarsal IV there is a distinct facet for the reception of metatarsal V. The bony wall of metatarsals I through IV is partly collapsed. Lateral to the contact with the calcaneum the surface of metatarsal V is recessed into a shallow fossa. Distally, metatarsal V forms a rounded articular head for the first phalanx of digit five. Lateral to that there is a distinct rounded process, possibly representing a lateral plantar tubercle (p. 73). An "outer process" with a distinct tuberosity is developed proximo-laterally (p. 73). The lateral margin of metatarsal V is concave and thickened.

The metatarsals and the phalanges of digits one and two form articulated series. The ungual phalanx of digit three is displaced, as are the three articulated distal phalanges of digit four and the two articulated distal phalanges of digit five. Finally, the first phalanx of digit five is displaced across the distal ends of metatarsals III and IV, and lies at right angles to the second phalanx of digit five. Like *T. meridensis*, MSNM V 3730 was collected in the Meride Limestone of Landinian age. *T meridensis* is probably conspecific with *T. longobardicus* (see "Introduction"). However, pending the format revision of taxonomy, MSNM V 3730 is provisionally considered as *Tanystropheus* cf. *longobardicus*.

Fig. 35 – *Tanystropheus* cf. *longobardicus*, MSNM V 3730, right pes in plantar view. I-V = metatarsals. Scale bar 10 mm. Preparation: Giuseppina Damiano. Photo: Luciano Spezia.

DISCUSSION

Discussion and interpretation of the skull anatomy of *Tanystropheus*: a new reconstruction

In spite of the large number of specimens of *T. longobardicus* recovered during excavations in the Besano Formation (=*Grenzbitumenzone* in the Swiss geological literature) the strong compression of these fossils together with the frequent disarticulation of various elements have been limiting factors in our interpretation. This is especially true for the skull. Skulls of *T. longobardicus* in the PIMUZ Collections that are more or less complete are those of the large-sized specimens PIMUZ T 2790 (Wild, 1974: pl. 14) and PIMUZ T 2819 (Wild, 1974: figs. 5-6, pls. 15-16), and that of the small-sized specimen PIMUZ T 2791 (Wild, 1974: figs. 3-4; Fig. 38 in this paper). The latter was first briefly described by Peyer (1931). Wild (1974) gave a more complete description, mainly based on X-radiographic plates (Wild, 1974: fig. 3). However, this specimen is severely crushed, and its interpretation very difficult.

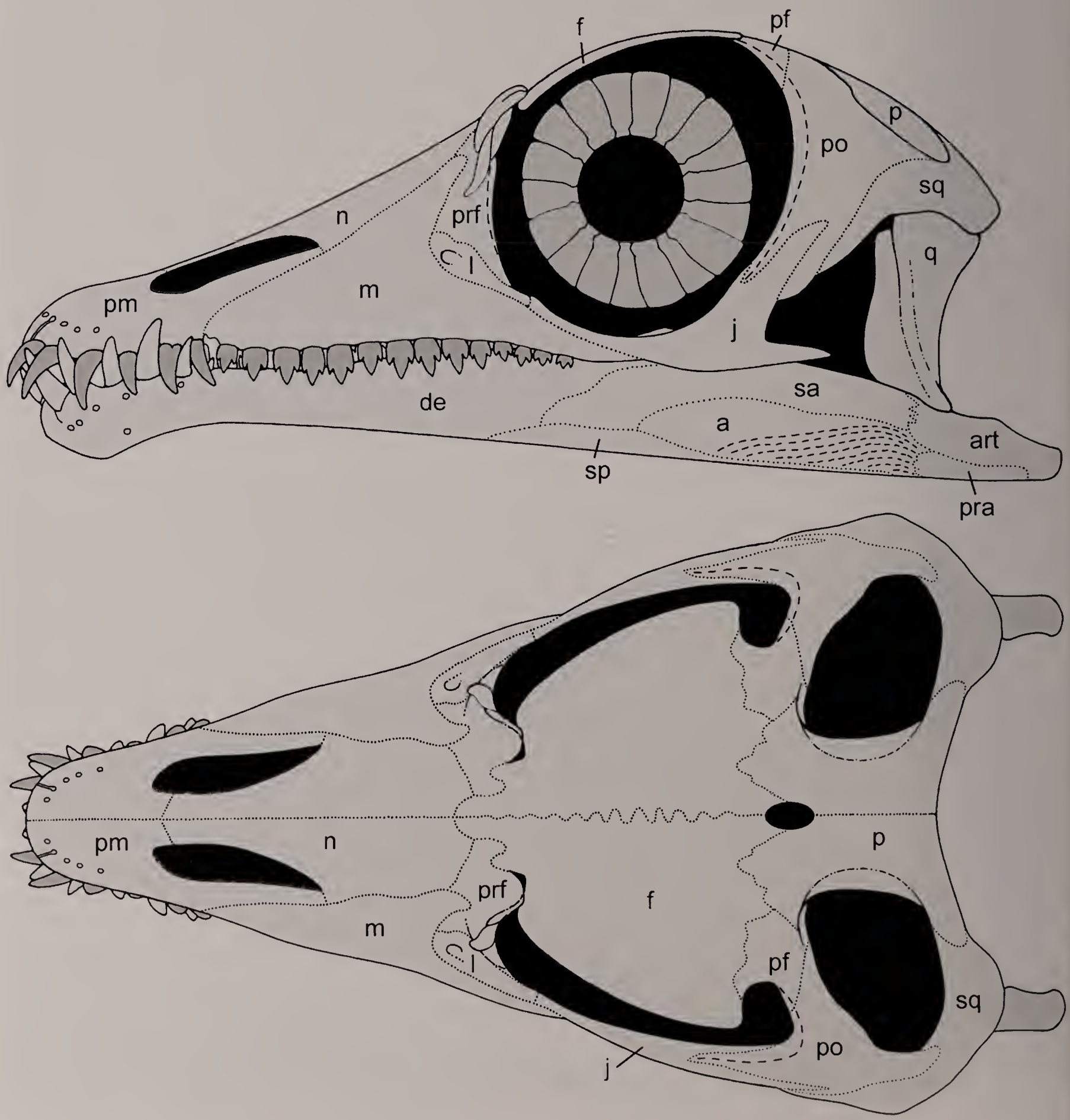

Fig. 36 – *Tanystropheus longobardicus*, reconstruction of the skull in the small-sized specimens. See discussion on pp. 44-62. Drawing: Massimo Demma.

Another quite complete small-sized skull, PIMUZ T 3901 (Fig. 39), is somewhat better preserved. This specimen, however, was referred by Wild (1980a) to a separate species, *T. meridensis* (see "Introduction" for discussion).

The new specimens from Besano described here, particularly the remarkably well preserved MSNM BES SC 1018, offer valuable new evidence on the morphology of the skull in *Tanystropheus*.

In providing this new reconstruction of the skull (Figs. 36-37), three points should be considered.

Firstly, the reconstruction of the skull of *Tanystropheus* presented here is only applicable to small-sized representatives of *T. longobardicus* (or, alternatively, to the representatives of a small-sized species of *Tanystropheus*, see p. 8) and also to *T. meridensis*. Differences in the shape and/or size of skull elements between small- and large-sized PIMUZ specimens were observed but are not discussed in any detail.

Secondly, the ventral and occipital views of the skull were not reconstructed in detail. The elements of the dermal palate and of the neurocranium are too poorly preserved and/or exposed in the new specimens, so they add nothing further to the previous descriptions. The extent of the dermal palate and the occiput in the model is consistent with the reconstruction of Wild (1974: fig. 8).

Thirdly, in the words of Underwood (1970: 2): when looking at the reconstruction, "I hope that readers will accept the more extended flights of speculation as intended to provoke discussion rather than to state positions firmly held".

The drawings in Figs. 36 and 37 were developed from a clay model, that was used to test the proportions and the nature of the contacts between adjacent elements of the skull in the three dimensions. The final reconstruction resulted from a complex procedure, in which different actions were performed simultaneously, each affecting each other, so that slight adjustments were continuously necessary. As a first step, an unfinished model was made approaching the general proportions of the skull in MSNM BES SC 1018 and in PIMUZ T 2484, as reconstructed by Wild (1974: figs. 7 a, 8). Indeed, PIMUZ T 2484 shows very similar proportions of the skull bones to those of MSNM BES SC 1018. Precise paper templates of the bones were then made from MSNM BES SC 1018 (Figs. 10-13) and PIMUZ T 2484 (Figs. 40, 43, 48, 50-52), and applied to the rough model, which was consequently modified. The three-dimensional proportions of the individual skull elements and their respective contacts were finally adjusted working directly on the model, paying attention to how each change affected the overall configuration of the skull. The squamosal was reconstructed based on MSNM BES SC 265 (Figs. 2-3) and PIMUZ T 2791 (Fig. 38).

Premaxilla and Maxilla

The premaxilla and maxilla of MSNM BES SC 1018 are very similar in proportions and shape to the same elements in PIMUZ T 2484 (Wild, 1974: figs. 2, 82, 83, pl. 18; Fig. 43 in this paper), in PIMUZ T 2791 (Wild, 1974: fig. 4; Fig. 38 in this paper) and in *T. meridensis*

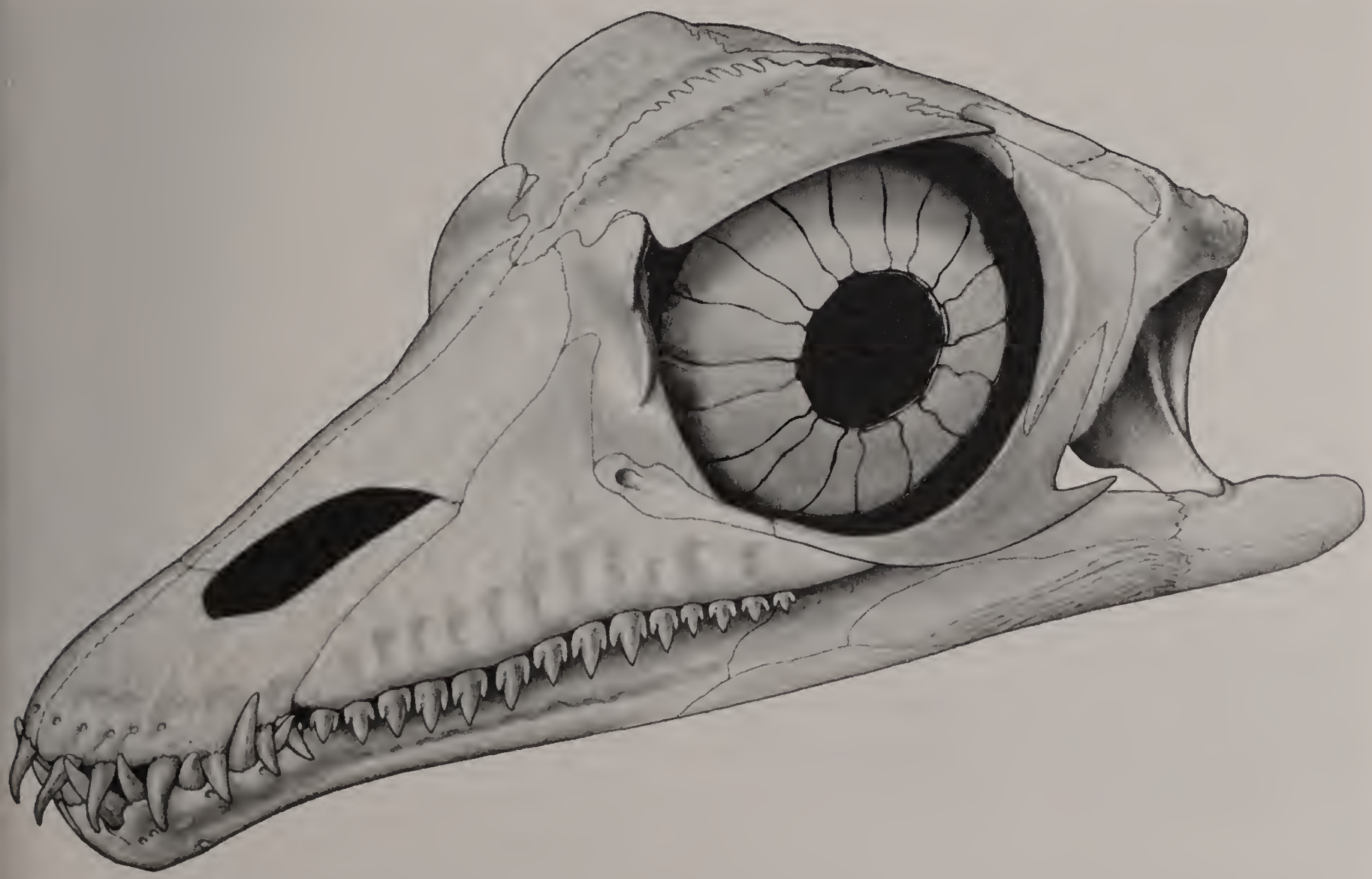

Fig. 37 – *Tanystropheus longobardicus*, three-dimensional reconstruction of the skull in the small-sized specimens. See discussion on pp. 44-62. Watercolor: Massimo Demma.

Fig. 38 – *Tanystropheus longobardicus*, PIMUZ T 2791, skull. Scale bar 10 mm. Photo: Heinz Lanz, PIMUZ.

(Wild, 1980a: fig. 1; Fig. 39 in this paper). There are some distinctive features common to all these specimens but not present in the large-sized individuals. The premaxilla forms a long and slender maxillary process, and a short, yet distinct nasal process. The maxilla is triangular in shape anteriorly - without a premaxillary process (*sensu* Wild, 1974: 9, fig. 82) - and forms a very well developed dorsal process.

The nature of the sutural contact between the premaxilla and the maxilla is quite clear, and invariably the same in all the skulls of the small-sized specimens. As can be seen in PIMUZ T 2484 (Fig. 43), the antero-lateral surface of the maxilla has a deep furrow, matching the maxillary process of the premaxilla. *T. meridensis* (Fig. 39), in which the contact between the premaxilla and maxilla can be seen both laterally (left side of the skull) and medially (right side of the skull), confirms that the maxillary process of the premaxilla overlaps the maxilla laterally, fitting into the maxillary furrow. According to Wild (1974: 9; see also reconstructions in figs. 7 a, 8, 10 a) the dorsal process of the maxilla were overlapped by the nasal and the prefrontal. However, the nature of the contact between the three bones remains not completely clear, and cannot be seen in either MSNM BES SC 1018 or in any PIMUZ specimen. My hypothesis is that the dorsal process of the maxilla was not concealed by the nasal and prefrontal (see "Nasal" and "Prefrontal").

Nasal

In the majority of known *T. longobardicus* specimens the nasals are not preserved. A fragmentary, isolated nasal is preserved in the large specimen PIMUZ T 2818 (Wild, 1974: pl. 12), and both nasals are completely preserved, albeit isolated, in the small PIMUZ T 2484 (Fig. 40). Finally, in *T. meridensis* the nasals are preserved in situ but severely crushed (Fig. 39). According to Wild (1974: 9), a loose junction of the nasals with the frontals would account for the nasals being invariably present as isolated elements (or completely missing). It seems likely that the nasals had very loose contacts with all the neighbouring bones. Consequently, the nature of these contacts is very difficult to reconstruct.

According to Wild's hypothesis (1974: fig. 8) the nasals overlapped the dorsal process of the maxillae, and were overlapped by the prefrontals and the frontals. In the known *Tanystropheus* specimens, however, there is no evidence for the nasal overlapping the dorsal process of the maxilla. The latter is fully exposed both in PIMUZ T 2791 (Fig. 38) and in MSNM BES SC 1018. In these specimens no nasal is preserved. However, I assume that the nasals in *T. meridensis* are preserved in situ (Fig. 39), crushed medially against the dorsal process of the maxilla which is also fully exposed (contra Wild, 1980a: 5, I clearly identified a well developed dorsal process of the maxilla in *T. meridensis*). This condition of preservation suggests that the nasal was positioned medial to the dorsal process of the maxilla, rather than overlapping it. It is possible that the lateral margin of the nasal and the dorsal margin of the maxilla established a syndesmotic, unossified contact. It is difficult to ascertain whether the nasals were overlapped by the prefrontals and the frontals, but I assume that such was the case (see "Frontal" and "Prefrontal").

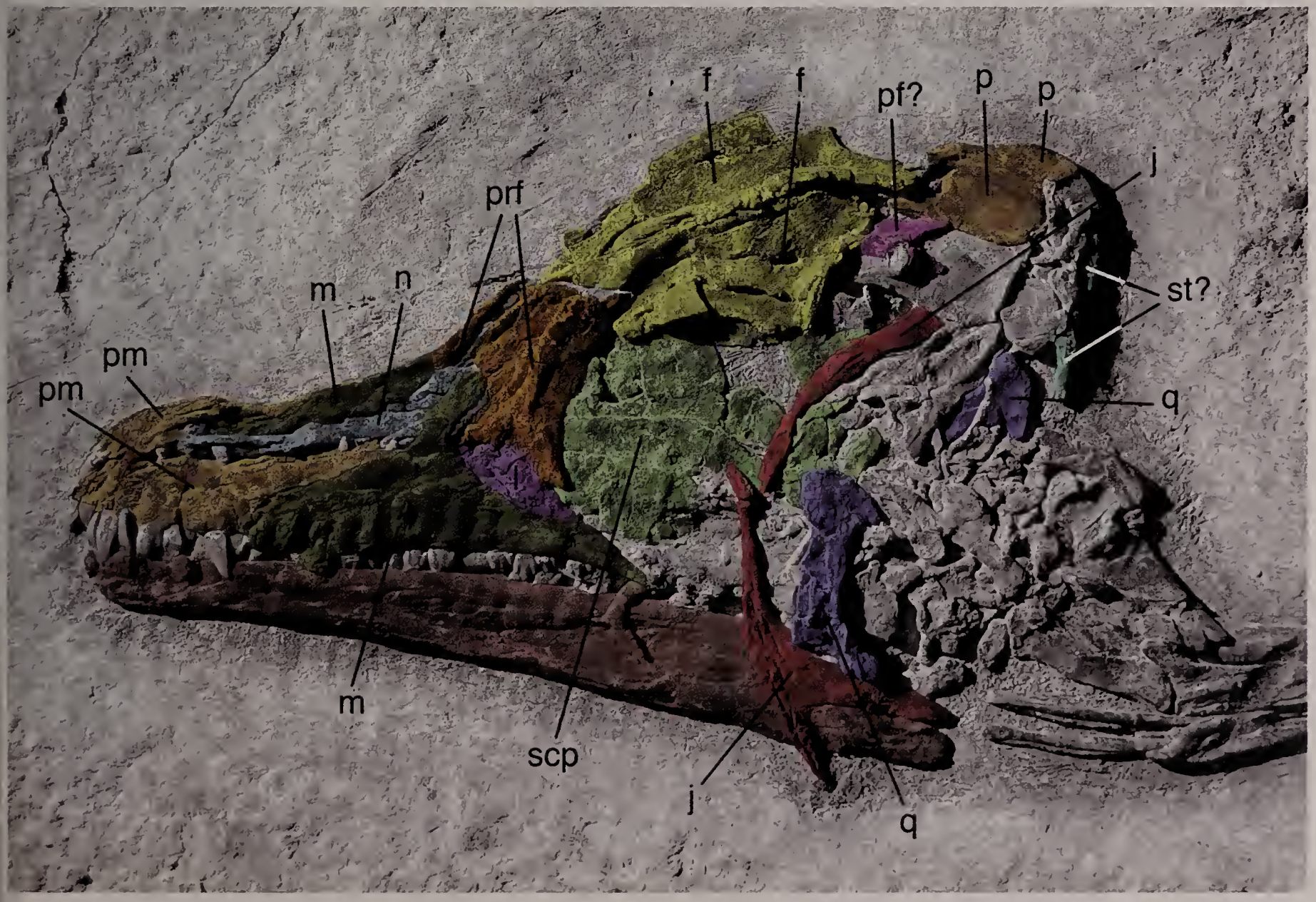

Fig. 39 – *Tanystropheus meridensis*, PIMUZ T 3901, skull. Scale bar 10 mm. Photo: Heinz Lanz, PIMUZ.

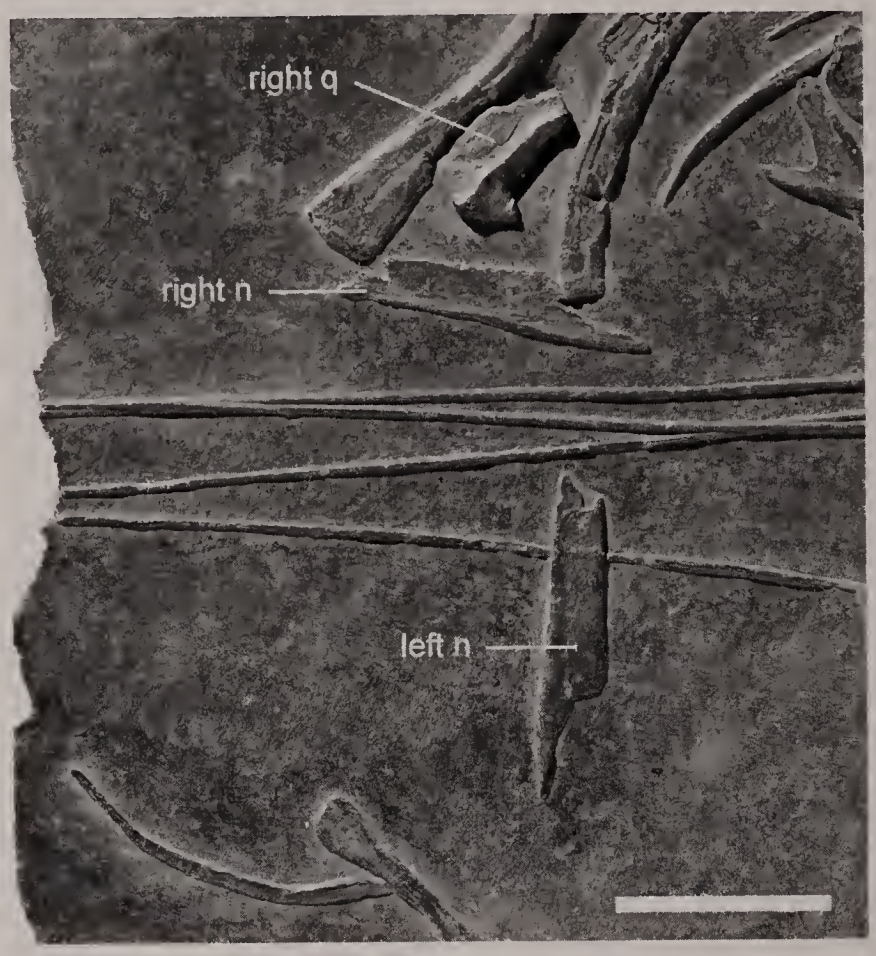

Fig. 40 – *Tanystropheus longobardicus*, PIMUZ T 2484, nasals. Scale bar 15 mm. Photo: Heinz Lanz, PIMUZ.

The general shape and proportions of the nasals were drawn based on those of PIMUZ T 2484 (Fig. 40) but slightly modified to fit them into the model and to obtain elongate external nares. Elongation of the external nares was inferred from *T. meridensis* (Fig. 39), in which the entire length of the maxillary process of the premaxilla forms the latero-ventral margin of the external naris.

Frontal

In MSNM BES SC 1018 the frontals are paired bones, as they are in the small-sized PIMUZ specimens (Wild, 1974: 10), in which the suture between the two elements is partly identifiable.

In all specimens of *T. longobardicus* the frontals display large lateral axe-shaped flanges (*die Orbitallamellae* or orbital laminae *sensu* Wild, 1974: 10). Wild (1974: 10) stated that these flanges were flattened because of compression but were originally slanting latero-ventrally, (Wild, 1974: figs. 7 a, 8). By contrast, I think that the condition of preservation reflects the original shape of the frontals. In all the PIMUZ specimens, isolated frontals are invariably preserved with horizontal lateral flanges (Figs. 41-43). In the complete skulls, preserved in lateral or dorso-lateral view, there is no evidence for a vertical orientation of the flanges.

Fig. 41 – *Tanystropheus longobardicus*, PIMUZ T 2482, fronto-parietal plate in ventral view. The arrow points to the fronto-parietal suture. Scale bar 6 mm. Photo: Nicholas C. Fraser.

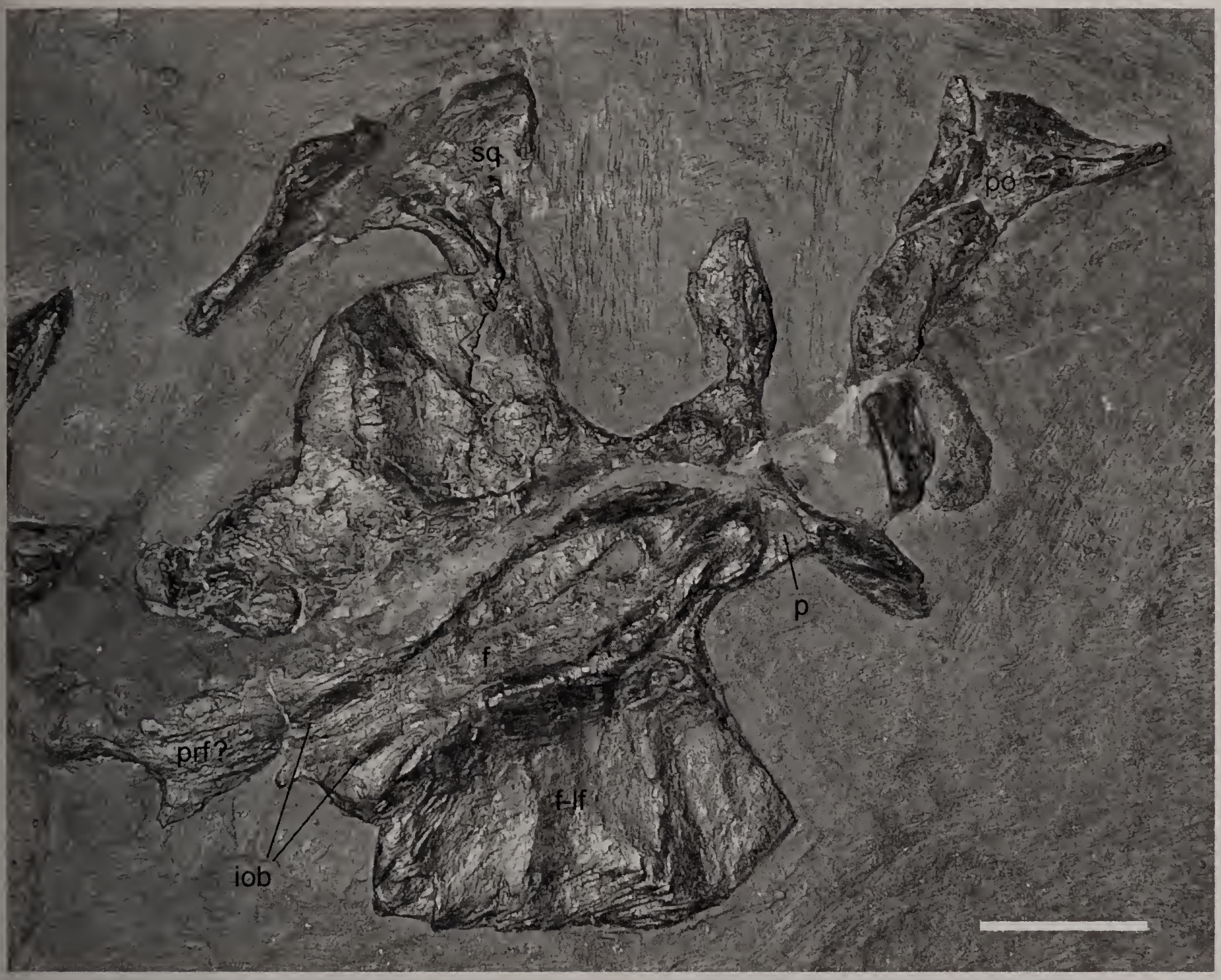

Fig. 42 – *Tanystropheus longobardicus*, PIMUZ T 2787, fronto-parietal plate in ventral view. Scale bar 10 mm. Photo: Nicholas C. Fraser.

In *T. meridensis* (Fig. 39) the two frontals rotated as a single unit and they clearly lie on one plane, with the dorsal surface exposed. The same is probably true for PIMUZ T 2791 (Wild, 1974: figs. 3-4; Fig. 38 in this paper), although this specimen is difficult to interpret because of extensive crushing. In MSNM BES SC 1018 (Figs. 10-12) there is no evidence that the lateral flanges were oriented latero-ventrally. The left frontal was raised upwards, exposing the entire ventral surface of the lateral flange, rather than extending into the orbit as it would have been expected if the lateral flange formed a medial wall to it. In MSNM BES SC 265 (Figs. 2-3), which is preserved in ventral view, the lateral flanges of the frontals are seen as bony laminae roofing the orbits. The horizontal orientation of the lateral flanges of the frontals in the model (Figs. 36-37) is consistent with the general proportions of the skull.

The frontal plate of MSNM BES SC 1018 was reconstructed duplicating the left frontal (exposed in ventral view). As a result, the frontal plate in ventral view (Fig. 44) closely resembles that of PIMUZ T 2787 (Fig. 42). Paired sinuous ridges characterize the ventral surface of the frontals (Figs. 41-42, 44). These ridges prosecute posteriorly on the ventral surface of the parietals (see "Parietal"). Contra Wild (1974: 10). I do not consider these ridges to mirror structures on the dorsal surface of the frontal, in particular the supraorbital ridges or *die Supraorbitalkanten sensu* Wild (1974: 10, fig. 2). According to Wild, the supraorbital ridges on the dorsal surface of the frontals formed the dorsal margin of the orbits and of the vertical orbital laminae and they were impressed upon the ventral surface through compression. It is not clear what constitutes the *cristae cranii frontalis* considered by Wild (1974: 10) a feature of the ventral surface of the frontals. Unequivocal evidence that the sinuous ridges represent real features of the ventral surface of the frontal plate is provided by the correspondence of the skeletal anatomy to that of the soft parts. By comparison with casts of the endocranial cavity in extinct and extant reptiles (Hopson, 1979), it is clear that the shape of the sinuous ridges on the frontal plate corresponds to the outline of the forebrain (see also Wild, 1974: 10). This is further confirmed by the presence on the ventral surface of the anterior process of the frontal plate (see below) of the oval impressions of the olfactory bulbs

Fig. 43 – *Tanystropheus longobardicus*, PIMUZ T 2484, fronto-parietal plate in dorsal view. The arrows point to articular facets, see discussion on p. 51. Scale bar 10 mm. Photo: Nicholas C. Fraser.

(Figs. 41-42). Hopson (1979: figs. 1-2) compared endocasts made from the skull of small and medium-sized specimens of the extant *Caiman crocodilus* and observed that changes in endocast proportions reflect changes in forebrain shape during ontogeny. In particular, in smaller individuals the cerebral cast is proportionally wider and in larger individuals it is narrower. Interestingly, the shape of the sinuous ridges on the ventral surface of the frontal plate in the small PIMUZ T 2482 is slightly different from the larger PIMUZ T 2787. This might be due to individual variation or alternatively be related to changes in forebrain shape.

In the frontal plate of *T. meridensis* (Fig. 39), exposed in dorsal view, Wild (1980a) described a thick supraorbital ridge continuous with the orbital margin of the prefrontal. I interpret this ridge as the medial contact between the two frontals. The medial relief on the frontal plate of *T. meridensis* is at least partly due to compression of the two frontals against the other. However, the right frontal of MSNM BES SC 1018, with a strongly thickened and sculptured medial margin, suggests that there was a raised area where the two frontals met.

A tripartite anterior process (nasal process *sensu* Wild, 1974: 10) formed by the two frontals such as seen in PIMUZ T 2484 (Fig. 43) is apparently not conspicuous in MSNM BES SC 1018. The shape of this process results from the contact of the anterior ends of the frontals. As described in MSNM BES SC 1018 (p. 21, Fig. 12), the anterior end of the main body of the frontal is bifurcate, forming two lobes. In this specimen the lateral lobe is seen lateral (dorsal, as preserved) and the medial lobe is seen medial (ventral, as preserved) to the interlocking prefrontal. The medial lobe in MSNM BES SC 1018 is apparently very short, so that if the anterior end of the left frontal is duplicated, a very short anterior process of the frontal plate results. I emphasize, however, that an elongate triangular fragment of bone is preserved in MSNM BES SC 1018 anterior to the medial lobe (Fig. 11), and this might be interpreted as an anterior continuation of the lobe itself, which as a consequence would be longer. Considering also that a tripartite, well developed anterior process of the frontal plate is invariably present in all PIMUZ specimens (Figs. 41-43), I reconstructed it in the model.

The dorsal surface of the anterior process can be seen in PIMUZ T 2484 (Fig. 43). It shows paired articular facets on each side, one between the medial and lateral lobes, the other in the notch between the anterior process and the lateral flange of the frontal. Wild (1974: 10, fig. 2) thought that the fronto-parietal plate of PIMUZ T 2484 was preserved in ventral view, and related the presence of the facets on the anterior process of the frontal plate to a contact with the nasals and prefrontals. According to Wild (1974: 9-10), both these elements were overlapped by the frontals. He assumed that the anterior process of the frontal plate "fit[ted] in between the nasals on the dorsal side", and that it was almost completely covered by the prefrontals on the ventral side. However, Wild did not state precisely which elements were received in the articular facets on the anterior process, and concluded that the nature of the contacts between the frontals, nasals and prefrontals was very complex.

The medial articular facets on the dorsal side of the anterior process of the frontal plate in PIMUZ T 2484 might be for the receptions of the nasals. However, the medial margin of the nasals of PIMUZ T 2484 (Fig. 40) is not notched posteriorly. This indicates that if the articulated nasals had overlapped the anterior process of the frontal plate they would have completely concealed it. By contrast, evidence from PIMUZ T 2484 is that the median part of the anterior process between the two articular facets was exposed on the dorsal side of the skull roof. Consequently, I assume that the nasals were overlapped by the anterior process of the frontal plate. However, the nature of the contact between the nasals and the frontals remains unclear.

In MSNM BES SC 1018, the prefrontal and the frontal are still fully articulated (p. 24) in an interlocking suture, exposed in ventral view. The frontal process of the prefrontal is received into a notch between the medial and lateral lobes of the anterior process of the frontal. In dorsal view, this notch corresponds to the margin of the articular facet between the two lobes. I assume that the frontal process of the prefrontal was directed medially and contacted the anterior process of the frontal in an oblique suture. Dorsally, the prefrontal overlapped the medial facet of the anterior process, ventrally, the margin of the prefrontal met the margin of the medial facet.

The lobe of the prefrontal (p. 24, Figs. 12, 37) apparently does not reach the facet on the notch between the anterior process and the lateral flange of the frontal. Moreover, the margin of the lobe is thickened and rounded, suggesting that it was probably free. At the same time, if the lobe of the prefrontal did not reach the lateral facet on the anterior process of the frontal plate, the latter facet remains unexplained.

Based on the well preserved right parietal of MSNM BES SC 1018, the frontals fitted posteriorly in a V-shaped embayment formed by the parietals (Fig. 44). As a result, the parietal foramen is partly delimited by the frontals. A similar morphology is seen in PIMUZ T 2482 (Fig. 41). By contrast, in PIMUZ T 2484 (Fig. 43), preserved in dorsal view, the frontals contact the parietals in an unequivocal interdigitating suture which is positioned anterior to the parietal foramen. These differences in the fronto-parietal contact are probably due to individual variation.

The posterior contact of the frontals with the postfrontals is discussed under the heading "Postfrontal".

Parietal

The parietals of MSNM BES SC 1018 and MSNM BES SC 265 conform to Wild's statement (1974: 11) that the parietal plate is formed by two separate elements. They are completely fused in the large-sized specimens in the PIMUZ Collections, while a suture between the two elements is still partly identifiable in the small-sized specimens.

The parietals were reconstructed in ventral view (Fig. 44), largely based on MSNM BES SC 1018 (right parietal, Figs. 10-12). The reconstructed parietals are very similar to those of PIMUZ T 2482 (Fig. 41; see also Wild, 1974: fig. 2, where, contra Wild, the parietals drawn in ventral view are clearly those of PIMUZ T 2482, not of PIMUZ T 2484). The assumption that the parietals of PIMUZ T 2482 are preserved in ventral view is consistent with the shape of the frontals in the same view, as interpreted above. As for the frontals, I consider that the condition of preservation of the parietals reflects their original morphology, and that the relief on the ventral surface of the parietals is not a direct result of compression causing the relief on the dorsal surface to be impressed upon it. The morphology of the ventral surface of the parietals conceivably mirrors that of the soft parts in the cerebellar region of the brain (see also "Frontal" and Wild, 1974: 11).

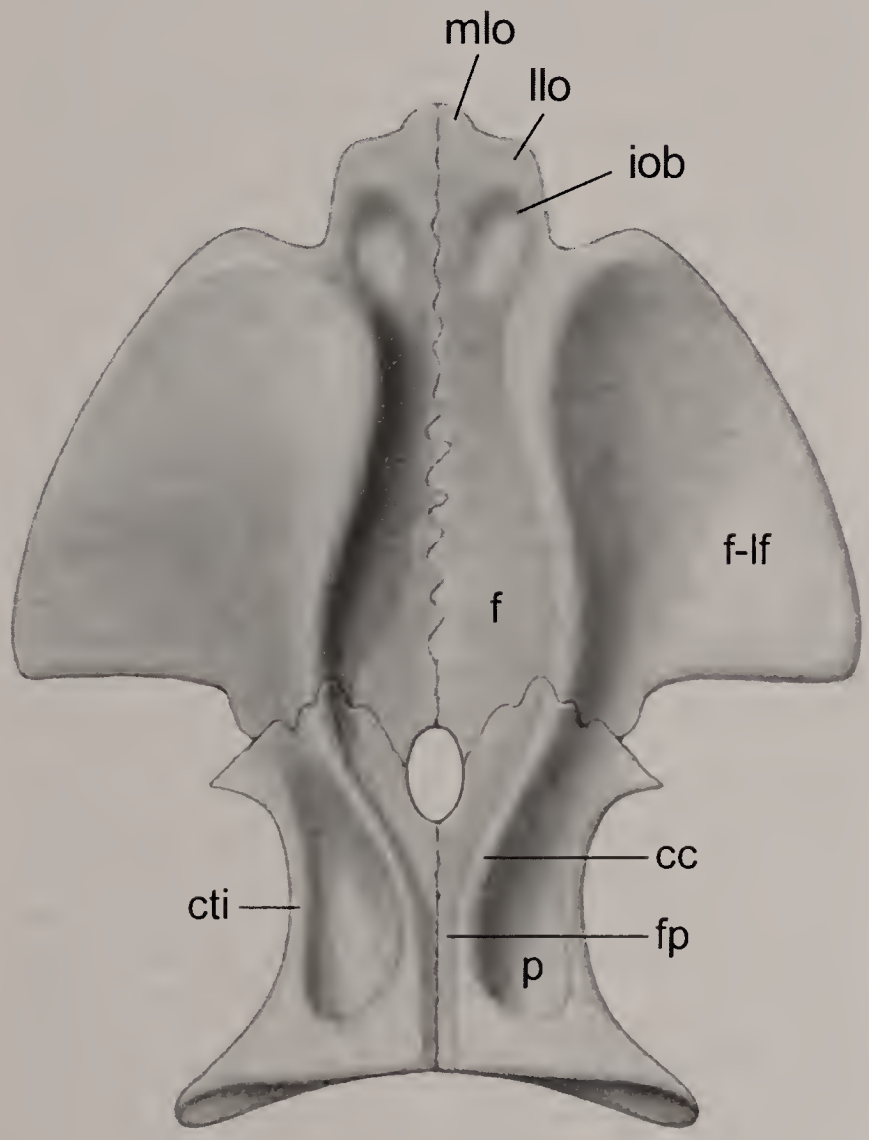

Fig. 44 – *Tanystropheus longobardicus*, reconstruction of the fronto-parietal plate in ventral view based on MSNM BES SC 1018. Watercolor: Massimo Demma.

In the model, the contact between the parietals and the frontals was reconstructed based on MSNM BES SC 1018 (see "Frontal"), while that between the parietals and the postfrontals (see "Postfrontal") was inferred from PIMUZ T 2484 (Fig. 43). The lateral supratemporal processes were reconstructed on the basis of MSNM BES SC 265 and the PIMUZ specimens. The supratemporal processes overlap the squamosals and possibly the supratemporals (see "Supratemporal"), as can be inferred from the presence of a facet on their ventral surface in MSNM BES SC 265 (Figs. 2-3) and PIMUZ T 2482 (Fig. 41), and from the articulated squamosal in the large PIMUZ T 2819 (Wild, 1974, figs. 5-6). Finally, in the parietals in dorsal view I assumed the presence of lateral obliquely slanting flanges (*die Temporalflügel* or parietal laminae *sensu* Wild, 1974: 11) but there is no clear evidence for them either in the new specimens or in the small-sized PIMUZ specimens. They are only unequivocally present in the large PIMUZ T 2819 (Wild, 1974: figs. 5-6).

The ratio between the length of the parietals relative to the overall length of the fronto-parietal plate resulting from the reconstruction in MSNM BES SC 1018 is congruent with that observed in PIMUZ T 2484 (Fig. 43). In the larger PIMUZ T 2482 (Fig. 41) and PIMUZ T 2787 (Fig. 42) the ratio is progressively higher. The relative length of the frontal and the parietal changes, with the parietal increasing and the frontal decreasing with increasing overall size.

Supratemporal

Wild (1974: 12) claimed the presence of supratemporals in *T. longobardicus* on the basis of an element interpreted as a supratemporal preserved in situ in the large-sized PIMUZ T 2819. Paired rod-shaped small bones might be interpreted as supratemporals in MSNM BES SC 265 (p. 12, Figs. 2-3). For the present the occurrence of supratemporals in *T. longobardicus* is equivocal and it is therefore impossible to describe the nature of their contacts with the neighbouring bones.

Prefrontal

The prefrontal of MSNM BES SC 1018 is very similar to the prefrontal of *T. meridensis* (Fig. 39) but different from the prefrontals as described and figured by Wild (1974: 10, figs. 8-9) in the specimens of *T. longobardicus* in the PIMUZ Collections.

In Wild's reconstructions (1974: figs. 8-9), the prefrontals extend in a antero-posterior direction and only form the antero-dorsal margin of the orbits. Further ventrally, the anterior margins of the orbits are formed by the lacrimals. The prefrontals overlap both the dorsal process of the maxillae and the nasals with a process (anterior process) extending anteriorly far beyond the fronto-nasal contact. Medially, they contact the frontal (frontal process), extending posteriorly beyond the fronto-nasal contact. The "orbital lamina" of the prefrontal is continuous with the "orbital lamina" of the frontal. Wild also maintained that the prefrontals reached the palatine with a palatine process.

Among the small-sized PIMUZ specimens, Wild (1974: 10) identified a prefrontal preserved in situ in PIMUZ T 2485 and an isolated prefrontal in PIMUZ T 2795. It is on the latter that he based the drawing in fig. 2 and the reconstruction in fig. 8. However, in Wild's drawing of PIMUZ T 2485 (Wild, 1974: pl. 8) a prefrontal is not identifiable and in the radiograph of PIMUZ T 2795 (Wild, 1974: pl. 6) it is difficult to understand which element Wild was referring to as the prefrontal.

In MSNM BES SC 1018 (Figs. 10-12) and in *T. meridensis* (Fig. 39) the prefrontal mostly extends in a dorso-ventral direction and forms almost the entire anterior margin of the orbit. Based on MSNM BES SC 265 (p. 12, Figs. 2-3), I confirm that the prefrontal reached the palatine ventrally. In MSNM BES SC 1018 and in *T. meridensis* the prefrontal is located posterior to the dorsal process of the maxilla, and not overlapping it. Based on the interpretation of the contact between the frontal and the prefrontal (see "Frontal"), the latter element had to overlap the nasal in order to reach the anterior process of the frontal plate. The reconstruction presented here differs from Wild's (1974: figs. 8-9) in that the prefrontal does not extend far anteriorly beyond the fronto-nasal contact. Finally, the prefrontal is reconstructed in contact with the anterior process of the frontal plate only, positioned mainly anterior to the latter, not lateral to it. In the new reconstruction the "orbital laminae" of the frontal are horizontally, not vertically positioned as was assumed by Wild. Consequently, the orbital surface of the prefrontal contacts the ventral surface of the frontal more medially, and there is no continuity between an "orbital lamina" of the prefrontal and an "orbital lamina" of the frontal.

Among the large-sized PIMUZ specimens, Wild (1974: 10) identified the prefrontals in PIMUZ T 2787. According to Wild, the right prefrontal is isolated but complete (Wild, 1974: fig. 1), and it is very similar in shape to the prefrontal of the small-sized specimens (Wild, 1974: fig. 2). Wild also maintained that the left prefrontal of PIMUZ T 2787 (Fig. 42) is preserved in situ, and that it still contacts the maxilla and the frontal. However, he stated that it was not possible to unequivocally identify the margins of the three bones. Indeed, I could not identify any contact between the maxilla and the presumed prefrontal. Wild assumed that the prefrontal widely overlapped the ventral surface of the anterior process of the frontal but the presumed prefrontal of PIMUZ T 2787 does not. An alternative interpretation might be that the "prefrontal" in PIMUZ T 2787 is in fact a nasal but also in this case the nature of the contact with the frontal is not clear.

Lacrimal

A lacrimal was only reported by Wild (1974: 10, figs. 1, 2) for PIMUZ T 2795 and PIMUZ T 2787, and in both specimens it is an isolated bone. The lacrimal of PIMUZ T 2795 was figured by Wild (1974: fig. 2) as a triangular bone with no surface detail. The shape of the lacrimal of PIMUZ T 2787 as figured by Wild (1974: fig. 1) is comparable in shape to that of MSNM BES SC 1018, although the lacrimal foramen is more posteriorly located in PIMUZ T 2787. The lacrimal of MSNM BES SC 1018 documents for the first time a lacrimal of *T. longobardicus* preserved in situ, confirming Wild's reconstruction (1974: fig. 8 b). A lacrimal of approximately the same shape, size and position as that in MSNM BES SC 1018 was identified by Wild (1980a: fig. 1) in the skull of *T. meridensis* (Fig. 39).

Postfrontal

The new specimens provide very limited information on the morphology of the postfrontal, and no postfrontals are preserved in the majority of PIMUZ specimens. However, in PIMUZ T 2484 postfrontals are preserved still sutured to the frontals (Fig. 43; see also Wild, 1974: fig. 2). This specimen best clarifies the position, shape and contacts of the postfrontals in dorsal view. The postfrontals are subtriangular elements anteriorly contacting the horizontal flanges of the frontals, and medially the parietals (Fig. 43). The exact same configuration can be seen on the radiograph of the slightly larger PIMUZ T 2482 (Fig. 45). An articulated postfrontal is probably also preserved in the small PIMUZ T 2791 (Wild, 1974: 18, figs. 3-4; Fig. 38 in this paper) but this skull is severely crushed and the information it provides is limited. Finally, a postfrontal is probably preserved in *T. meridensis* (Wild, 1980a; Fig. 39 in this paper).

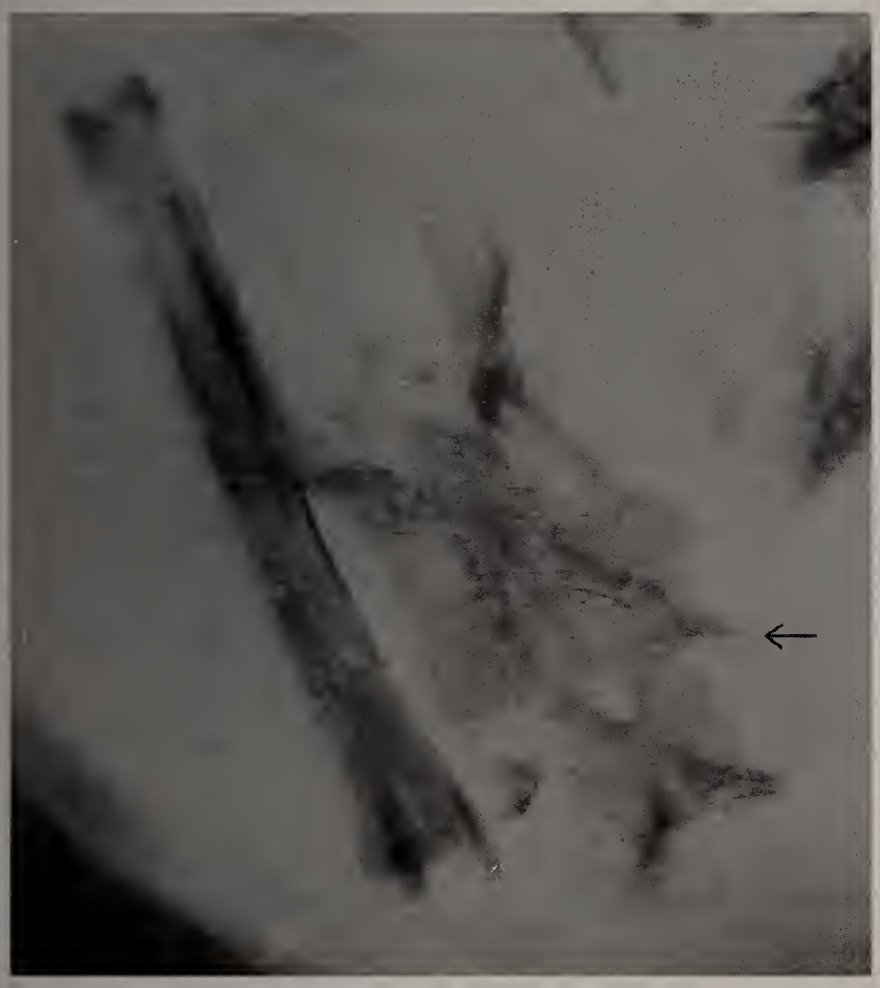

Fig. 45 – *Tanystropheus longobardicus*, PIMUZ T 2482, fronto-parietal plate, radiograph. The arrow points to the postfrontal. Courtesy PIMUZ.

In the large PIMUZ T 2819 (Wild, 1974: figs. 5-6), the left postfrontal appears to be at least partially preserved but it provides little detail. Wild (1974) claimed the presence of a postfrontal in PIMUZ T 2787 (Fig. 42), but there is no evidence of a suture between the frontal and the postfrontal as shown in Wild's fig. 1. Evidence from other specimens indicates that the presumed postfrontals in PIMUZ T 2787 represent the posterior part of the horizontal flanges of the frontals. In the large MSNM V 3663 (p. 38, Fig. 31) the right postfrontal is preserved, sutured to the skull roof in a manner similar to PIMUZ T 2819.

The postfrontal is therefore a very short element projecting laterally and ventrally, and sutured to the frontal and parietal. Its shape is similar in small- and large-sized specimens. However, the nature of its contact with the postorbital is not completely clear, due to the difficulties encountered in the interpretation of the temporal region of the skull (see below).

Squamosal and Postorbital

Wild (1974: 11) described the squamosal as a sickle-shaped element with a wide anterior postorbital process overlapping the postorbital, a pointed posterior parietal or supratemporal process overlapped by the supratemporal process of the parietal, and a quadrate process overlapping the cephalic condyle of the quadrate. Wild's description was evidently based on the small PIMUZ T 2791 (Wild, 1974: figs. 2-4; Fig. 38 in this paper), the larger PIMUZ T 2787 (Wild, 1974: fig. 1, pl. 9; Fig. 42 in this paper) and the large PIMUZ T 2819 (Wild, 1974: figs. 5-6).

The general shape of the left squamosal in MSNM BES SC 265 (p. 12) is very similar to that of the squamosal in Wild's (1974) fig. 2 (this element is not from PIMUZ T 2484, as stated by Wild but clearly corresponds to the isolated right squamosal of PIMUZ T 2791, see Fig. 38 in this paper). I suggest that this shape represents real features of the bone, and that the squamosal originally had a complex three-dimensional shape (Fig. 46) which cannot be seen in the fossils because the bone is crushed on the slab. The orientation of the posterior and anterior rami of the squamosal - and of its postorbital process - in the three dimensions shown in Fig. 46 might well produce the shape of the compressed squamosal described for MSNM BES SC 265 (p. 12). As the left squamosal of MSNM BES SC 265 is preserved in its original antero-posterior orientation, there is unequivocal evidence for the pointed process of the squamosal being the postorbital process (contra Wild, 1974: 11, fig. 2).

Wild (1974: 11, fig. 2) interpreted the postorbital as an elongate, subtriangular and flattened bone. Its long and pointed ventral jugal process overlapped the jugal, and the expanded dorsal end formed an anterior supraorbital process (orbital process *sensu* Wild, 1974), overlapping the postfrontal, and a posterior squamosal process, interlocking with the squamosal. Among the small-sized specimens, Wild identified isolated postorbitals in PIMUZ T 2484 (Wild, 1974) and *T. meridensis* (Wild, 1980a). While the element interpreted by Wild (1980a: fig. 1; Fig. 39 in this paper) as a postorbital in *T. meridensis* is probably a quadrate, it is not clear which element of PIMUZ T 2484 was identified by Wild as the postorbital. In the caption of fig. 1 Wild (1974) stated that the isolated postorbital illustrated was from PIMUZ T 2484 but he did not indicate which bone he identified as the postorbital in the "exploded" skeleton (Wild, 1974: pl. 18). It is possible that it is the element preserved to the right side of the fronto-parietal plate (labelled "po?" in Fig. 43), which is here considered as the right postorbital. In the same specimen there are remains of a bone overlapped by the left prefrontal which conceivably represent the left postorbital (see Fig. 43 in this paper and Wild, 1974: pl. 18, where the remains are labelled "postfrontal"). In the large-sized specimens in the PIMUZ Collections, Wild reported a postorbital for PIMUZ T 2819 (Wild, 1974: fig. 6). This fragmentary element, however, is in all probability a squamosal (Kuhn-Schnyder, 1967: fig. 3). Wild (1974) probably based the description of the postorbital

Fig. 46 – *Tanystropheus longobardicus*, reconstruction of the left squamosal in the small-sized specimens (see discussion on p. 53). A) Dorsal view. B) Ventral view. Drawing: Massimo Demma.

on the larger-sized PIMUZ T 2787 (Wild, 1974: fig. 1, pl. 9), in particular on the element labelled "po?" in Fig. 47. Two additional elements preserved in PIMUZ T 2787 (Fig. 42) were interpreted by Wild as the squamosals. The element labelled "po" in Fig. 42, however, is similar in shape to the putative postorbital described for MSNM BES SC 1018 (p. 24). Contra Wild (1974), I suggest that it represents a postorbital. Its shape is different from that of the element labelled "sq" in Fig. 42. In this latter element a laterally projecting posterior ramus and an antero-laterally oriented anterior ramus - with a tapering postorbital process bending medially - can be clearly seen. Therefore, I concur with Wild (1974) that this second element is indeed a squamosal. The preserved part of the right postorbital in MSNM V 3663 (Fig. 31) is conceivably the dorsal one, extending between the postfrontal and the squamosal, while the jugal process is assumed to be truncated.

The contacts of the squamosal and postorbital with the neighbouring bones are not completely clear.

Wild (1974: 11, 18) stated that both in the small-sized PIMUZ T 2791 (Wild, 1974: figs. 3-4) and in the large-sized PIMUZ T 2819 (Wild, 1974: figs. 5-6) there were squamosals preserved in situ, and he maintained that the articular relationships between the squamosal and the neighbouring bones, as indicated in the reconstructions presented in figs. 8 and 9 (Wild, 1974), were derived from these specimens. Contra Wild, I suggest that these elements only contact the parietal. Assuming Wild correctly identified the left squamosal in PIMUZ T 2791 on the stereo-radiographs (Wild, 1974: figs. 3-4), this element is oriented in the direction of the ascending process of the jugal, in a manner similar to the left squamosal in MSNM BES SC 265. It does not contact the postorbital antero-ventrally. In fact, a postorbital as described by Wild cannot be identified in PIMUZ T 2791. The element identified by Wild as the right squamosal in PIMUZ T 2819 is broken anteriorly, and again a right postorbital was not described by Wild in this specimen.

As in all the available material of *T. longobardicus* there are no articulated squamosals and postorbitals, the nature of the contact between these two elements remains unclear. However, the element tentatively identified as the right postorbital in PIMUZ T 2484 (Fig. 43) exhibits a posterior triangular and longitudinally elongate facet. This might be a facet for the reception of the postorbital process of the squamosal.

Wild emphasized (1974: 11) that the articular relationship between the postorbital and the postfrontal was not clear. Assuming that the fronto-parietal plate and the postfrontals in PIMUZ T 2484 (Fig. 43) were preserved in ventral view, Wild conjectured that the postorbital overlapped the dorsal surface of the postfrontal, because on the ventral surface of the latter a facet for the reception of the postorbital cannot be seen. Contra Wild, I assume that the fronto-parietal plate and the postfrontals in PIMUZ T 2484 are preserved in dorsal view. This would suggest that the postorbital was overlapped by the postfrontal. However, the presumed left postorbital is very fragmentary, and the nature of the contact between the postfrontal and the postorbital cannot be stated precisely. Articulated postfrontals and postorbitals are not preserved in other PIMUZ specimens. Specimens MSNM BES SC 265 and

Fig. 47 – *Tanystropheus longobardicus*, PIMUZ T 2787, presumed postorbital (see discussion on p. 54). Scale bar 20 mm. Photo: Nicholas C. Fraser.

MSNM BES SC 1018 add no information. Apparently, only MSNM V 3663 preserves a postfrontal in articulation with the postorbital (p. 38). According to Wild (1974: 11), a loose junction of the postorbital with the neighbouring elements would account for the postorbital being mostly preserved as an isolated element. In MSNM V 3663, however, the postfrontal and the postorbital seem to be steadily sutured (Fig. 31).

No articulated postorbitals and jugals are preserved in the PIMUZ material and the configuration of the contact between the two elements was here inferred from MSNM BES SC 1018 (p. 24).

The result of my interpretation of the temporal region of the skull is shown in Figs. 36-37. The posterior ramus of the squamosal and the posterior part of its anterior ramus lie on a plane slanting downwards. The anterior part of the anterior ramus of the squamosal (postorbital process) is deflected ventrally and medially, where it contacts the posterior side of the postorbital. The postorbital is represented as a triradiate element. Dorsally and anteriorly it contacts the postfrontal. Ventrally, the bifid jugal process of the postorbital contacts the jugal. The anterior ramus of the jugal process fits into the elongate fossa on the dorsal process of the jugal.

Comparison with the skull of the closely related *Macrocnemus* (Rieppel & Gronowsky, 1981: fig. 1; Premru, 1991: fig. 3; Renesto & Avanzini, 2002: fig. 2 A) and the more distantly related *Prolacerta* (Modesto & Sues, 2004: fig. 3) seems to lend further support for the presence of a triradiate postorbital and a short, triangular postfrontal in *Tanystropheus*. Both in *Macrocnemus* and *Prolacerta* the two elements are in loose contact. Interestingly, in the uncatalogued *Macrocnemus* PIMUZ specimen "Alla Cascina" (Rieppel & Gronowsky, 1981: fig. 1), the postorbital process of the squamosal contacts a long, horizontal posterior process of the postorbital along its entire ventral margin.

Jugal

A jugal is preserved in lateral view both in MSNM BES SC 265 and in MSNM BES SC 1018; in the latter specimen the bone is particularly well preserved in situ.

The comparison with the small- and large-sized specimens in the PIMUZ Collections revealed that a much taller dorsal or postorbital process characterizes the small-sized specimens by comparison with large-sized ones.

A feature that was not mentioned by Wild (1974) because it cannot be seen in the PIMUZ material is the presence of an elongate groove close to the orbital margin of the dorsal process. This groove is posteriorly delimited by a crest, which itself is positioned anterior to a shallow elongate fossa.

Quadrate

The left quadrate of MSNM BES SC 1018 is badly crushed but apparently similar in shape to the quadrate of *T. meridensis* (Wild, 1980a: fig. 1; Fig. 39 in this paper).

Wild (1980a) claimed that the shape of the quadrate was one of the diagnostic characters of the new species *T. meridensis*. According to him, the quadrate of *T. meridensis* would be taller, and more slender and concave posteriorly than in *T. longobardicus*.

Among the small-sized specimens of *T. longobardicus* in the PIMUZ Collections both quadrates are preserved as isolated elements in PIMUZ T 2484 (Wild, 1974: fig. 2). One of the two (left, Fig. 43), exposing its medial side according to Wild, is badly crushed. The other (right, Fig. 40), exposing its lateral side according to Wild, provides more detail. As compared to the quadrate of *T. meridensis*, the quadrate of *T. longobardicus* is apparently shorter and wider only because of the presence of a wide medial lamina. If the ratio between the height of the quadrate and the length of the maxilla is calculated, the height of the quadrate is approximately 50% of the length of the maxilla in *T. meridensis*, and approximately 40% in PIMUZ T 2484. In Wild's reconstruction (1974: fig. 8) based on PIMUZ T 2484, the height of the quadrate is approximately 45% of the length of the maxilla. Fitting the lower jaw into the model it became apparent that a height of the quadrate of approximately 47% of the length of the maxilla was required for the quadrate to bridge the distance between the squamosal and the articular fossa of the lower jaw (assuming that the lower jaw was not distorted). Significantly, the height of the quadrate so obtained falls within the range of 40-50% of the length of the maxilla observed in the PIMUZ specimens. As the left quadrate of MSNM BES SC 1018 is badly crushed and fragmentary, it is difficult to evaluate the presence of a medial lamina and its extent. The medial lamina of the quadrate in *T. meridensis* is apparently very short. However, part of the medial lamina might still be enclosed in the matrix in both these specimens. Finally, the quadrate of PIMUZ T 2791 (Wild, 1974: figs. 3-4; Fig. 38 in this paper), which is preserved *in situ* and exposed in lateral view, exhibits the same concave posterior margin as the quadrate of *T. meridensis*.

In conclusion, the quadrate of *T. longobardicus* probably had a shape similar to that described by Wild (1974) for the PIMUZ specimens, with an even wider medial lamina in the large-sized specimens compared to the small-sized ones. There is no appreciable differences in the shape and height of the quadrate in *T. longobardicus* and *T. meridensis*.

According to Wild (1974: 12, 25) the quadrate of *Tanystropheus* was streptostylyc. It was loosely articulated with the squamosal and, probably, the supratemporal, and had ligamentous connections with the opisthotic and the pterygoid. This interpretation cannot be verified in the new specimens.

Epipterygoid

The epipterygoid is not preserved in MSNM BES SC 1018. According to Wild (1974: 14, fig. 1), it is preserved only in the larger specimens among the material housed at the PIMUZ. An isolated epipterygoid is preserved in MSNM BES SC 265 (p. 12, Figs. 2-3), and, as stated by Wild, it is a rod-shaped element with expanded ends. As the contacts of this bone with other elements of the skull cannot be ascertained, it was not included in the reconstruction.

Neurocranium

Only some elements of the neurocranium are preserved in the new specimens. In particular, in MSNM BES SC 265 the basisphenoid-parasphenoid complex is clearly identifiable, while the other elements are badly crushed, and their interpretation is very difficult (p. 12). In MSNM BES SC 1018 I could only identify the supraoccipital (p. 24).

To assess whether the extent of the occiput reconstructed in the model was consistent with the proportions of other regions of the skull I attempted a reconstruction of the supraoccipital-exoccipitals-opisthotics complex in MSNM BES SC 1018 by direct comparison of its supraoccipital with that preserved in PIMUZ T 2484 (Fig. 43). I then extrapolated the proportions of the exoccipitals and opisthotic from their dimension in PIMUZ T 2484.

The lateral end of the reconstructed paroccipital processes of MSNM BES SC 1018 resulted very close to the quadrate but did not quite reach it. Wild (1974: fig. 8) came to the same conclusion. However, my reasoning was based on a paper template of the supraoccipital-exoccipitals-opisthotics complex, which does not take into account the thickness of the bone. Therefore a contact of the paroccipital process with the quadrate cannot be excluded.

Sclerotic ring

Wild (1974: 17) drew attention to the presence in the PIMUZ material of small, thin bony plates with a polygonal or rounded shape, and tentatively interpreted them as sclerotic plates. In *T. meridensis* (1980a: figs. 1-2) he again identified ten thin roundish-oval bony elements positioned within the orbit as sclerotic plates.

MSNM BES SC 1018 confirms the presence of a sclerotic ring in *Tanystropheus*. This specimen is the only one in all the available material that shows isolated plates with a definitive shape. In particular, four plates preserved dorsal to the skull indicate a subrectangular shape. Other elements, mostly with quite irregular shape, are preserved within the orbit.

The proposed reconstruction of the sclerotic ring (Figs. 36-37) should be considered provisional. Firstly, the possible size of an eye was determined on the size of the reconstructed orbit, followed by an estimate of the diameter of the cornea. While arranging the subrectangular sclerotic plates around the cornea, I established that the plates should follow the eye curvature, and that 18 plates were required to maintain the contact of the plates orbitally (*sensu* Underwood, 1970). As a result, the plates partly overlapped corneally (*sensu* Underwood, 1970). The reconstructed pattern of overlap is arbitrary.

Lower jaw

Within the small-sized *T. longobardicus* specimens in the PIMUZ Collections, complete lower jaws in situ are preserved in PIMUZ T 2791 (Wild, 1974: figs. 3-4; Fig. 38 in this paper). In this specimen the right lower jaw overlaps the left one to a large extent. Since the skull is also heavily crushed, PIMUZ T 2791 provides very little information for the reconstruction of the lower jaw. The left mandibular ramus is preserved in situ, exposed in lateral view, in the small *T. meridensis* (Wild, 1980a: fig. 3; Fig. 39 in this paper). Wild (1980a: 7; Fig. 49 F in this paper) maintained that the configuration of the different elements in the lower jaw of *T. meridensis* was similar to *T. longobardicus*.

In other "exploded" skulls of small-sized *T. longobardicus* specimens in the PIMUZ Collections, more or less complete lower jaws are preserved as isolated elements. Both dentaries, post-dentary parts, and isolated bones of the lower jaws are preserved in PIMUZ T 2484 (Figs. 48, 50-52). On the basis of this specimen Wild (1974: 40, figs. 15-16 a) reconstructed the lower jaw in lateral view for the small-sized *T. longobardicus* specimens. Specimen PIMUZ T 2482 (Wild, 1974: pl. 5) preserves the complete left lower jaw in medial view (Wild, 1974: fig. 27 b), as well as part of the dentary of the right lower jaw in lateral view. Indeed, PIMUZ T 2482 provides the most detail of the medial surface of the lower jaw within the PIMUZ material but it is not exhaustively informative. The fragmentary mandibular ramus of PIMUZ T 2779 (Peyer, 1931: fig. 3 in pl. 13, text-fig. 14) is too poorly preserved and adds no substantial information. Consequently, Wild reconstructed the lower jaw in medial view for the small-sized *T. longobardicus* specimens only tentatively (Wild, 1974: fig. 16 b), based on the configuration of the bones on the lateral side of the lower jaw and on isolated mandibular elements (Wild, 1974: 40, fig. 15) from PIMUZ T 2484 (coronoid and prearticular) and PIMUZ T 2795 (splenial).

Complete mandibular rami in lateral view are preserved in the large-sized specimens PIMUZ T 2787 (right lower jaw; Wild, 1974: pl. 9) and PIMUZ T 2819 (left lower jaw; Wild, 1974: figs. 5-6), while in PIMUZ T 2793 (Wild, 1974: figs. 18-19) the right lower jaw is heavily damaged, and the left one is broken into two pieces. The lateral surface of the lower jaw of the large-sized specimens of *Tanystro-*

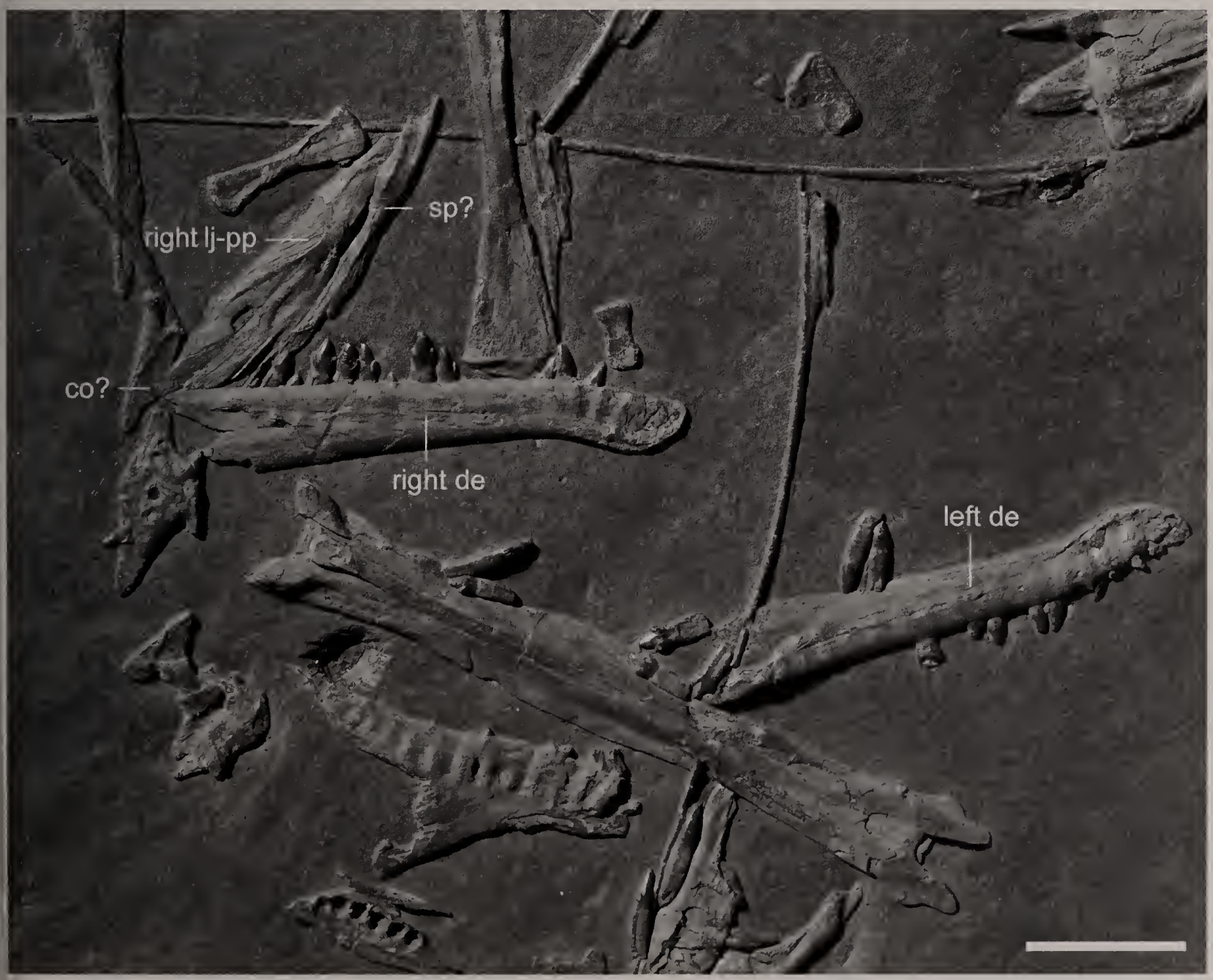

Fig. 48 – *Tanystropheus longobardicus*, PIMUZ T 2484, lower jaws. Scale bar 10 mm. Photo: Rosi Roth, PIMUZ.

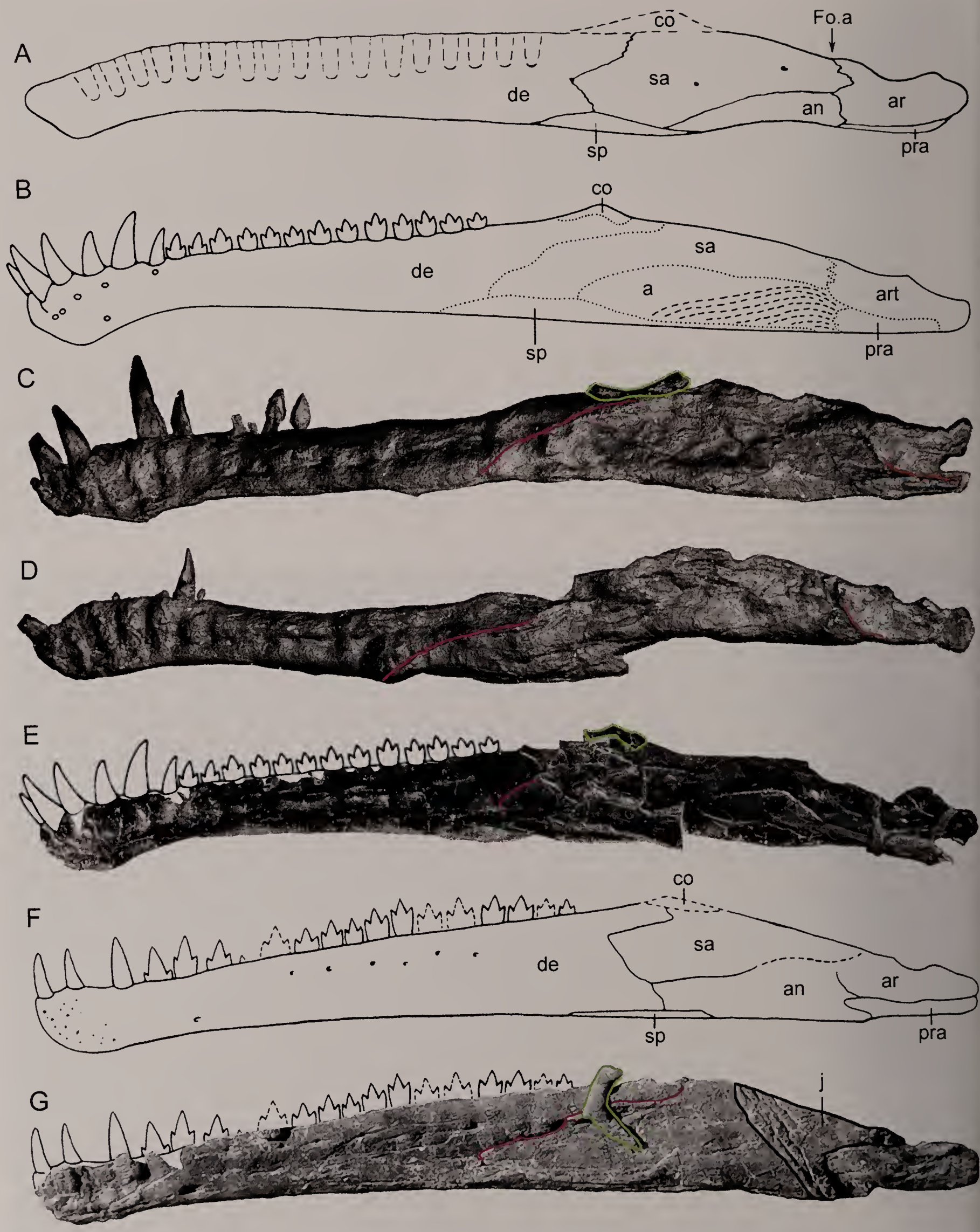

Fig. 49 – Lower jaws in small-sized specimens of *Tanystropheus* in lateral view, not to scale. A) *Tanystropheus longobardicus*, small-sized specimens, reconstruction of Wild (after Wild, 1974: fig. 16 a). B) *Tanystropheus longobardicus*, reconstruction of the author, drawing: Massimo Demma. C) *Tanystropheus longobardicus*, MSNM BES SC 265, left lower jaw, photo: Luciano Spezia. D) *Tanystropheus longobardicus*, MSNM BES SC 265, right lower jaw, reflected horizontally for easier comparison, photo: Luciano Spezia. E) *Tanystropheus longobardicus*, MSNM BES SC 1018, left lower jaw, photo: Luciano Spezia. F) *Tanystropheus meridensis*, PIMUZ T 3901, reconstruction of Wild (after Wild, 1980a: fig. 3). G) *Tanystropheus meridensis*, PIMUZ T 3901, left lower jaw, as interpreted by the author, photo: Heinz Lanz, PIMUZ. Pink lines: suture dentary-surangular. Green lines: presumed coronoid. Orange lines: suture articular-prearticular. See discussion on pp. 57-61.

pheus was reconstructed by Wild (1974: 40, fig. 17) on the basis of PIMUZ T 2819, the medial surface on the basis of radiographs of the right lower jaw of PIMUZ T 2787, and of a small fragment of the left lower jaw of the same specimen. Wild (1974: fig. 19) also provided a reconstruction of the lateral surface of the lower jaw of PIMUZ T 2793 but this is similar to that of PIMUZ T 2819.

As reconstructed by Wild, the nature of the contacts between the elements of the lower jaw, is similar in both small- and large-sized specimens of *Tanystropheus*.

A new reconstruction of the lower jaw in lateral view is presented here, based on MSNM BES SC 1018 (Figs. 13, 49 E), MSNM BES SC 265 (Figs. 2-3, 49 C-D), and PIMUZ T 2484 (Figs. 48-52), which is partly re-interpreted. The configuration of the mandibular elements on the medial side of the lower jaw remains not completely clear but the right lower jaw of MSNM BES SC 1018 (Fig. 53 B) provides new information on the shape of the splenial and prearticular.

By comparison with Wild's reconstruction (1974: fig. 16; Fig. 49 A in this paper), my reconstruction of the lower jaw in lateral view (Fig. 49 B) differs on three points. First, the surangular overlaps the dentary. Second, the angular is wider. Third, the splenial contributes to a larger extent to the ventral margin of the lower jaw.

Wild (1974: 38, figs. 15-16) maintained that the dentary overlapped the surangular, observing that the surangular was remarkably grooved anteriorly to establish a strong contact with the dentary. However, on both mandibular rami of MSNM BES SC 265, an oblique, dorsally convex suture is unequivocally present (Fig. 49 C-D), which can be identified as the contact between the dentary and the surangular. The same suture occurs in MSNM BES SC 1018 (left lower jaw, Fig. 49 E), albeit less distinct, and in *T. meridensis* (Fig. 49 G). In both isolated dentaries of PIMUZ T 2484 (Fig. 48) an oblique, dorsally convex line sets off a depressed area, suggesting that the dentary was overlapped by the surangular. In the post-dentary isolated part of the left lower jaw of the same specimen (Figs. 49, 51 B), the anterior part of the surangular displays a deepened surface dorsal to a sinuous line. I interpret this line to represent the suture between the dentary and surangular on the lateral surface of the lower jaw. I assume that, if observed anteriorly, the surangular would be excavated by a deep groove separating a medial and a lateral bony laminae, which are compressed one over the other in the fossil. The medial lamina would overlap the medial surface of the dentary, the lateral would overlap the lateral surface of the dentary. In other words, the dentary would fit into the groove between the two laminae. On the medial surface of the right lower jaw of MSNM BES SC 1018 (Fig. 53 B), however, the nature of the contact between the dentary and the surangular is not clear. Perhaps, a coronoid overlapped the area where the two bones met (see below).

Joining paper templates of the dentary and of post-dentary part of the jaw in PIMUZ T 2484, I observed that where the two elements met, on the ventral margin

Fig. 50 – *Tanystropheus longobardicus*, PIMUZ T 2484, post-dentary part of the left lower jaw in lateral view. Scale bar 5 mm. Photo: Rosi Roth, PIMUZ.

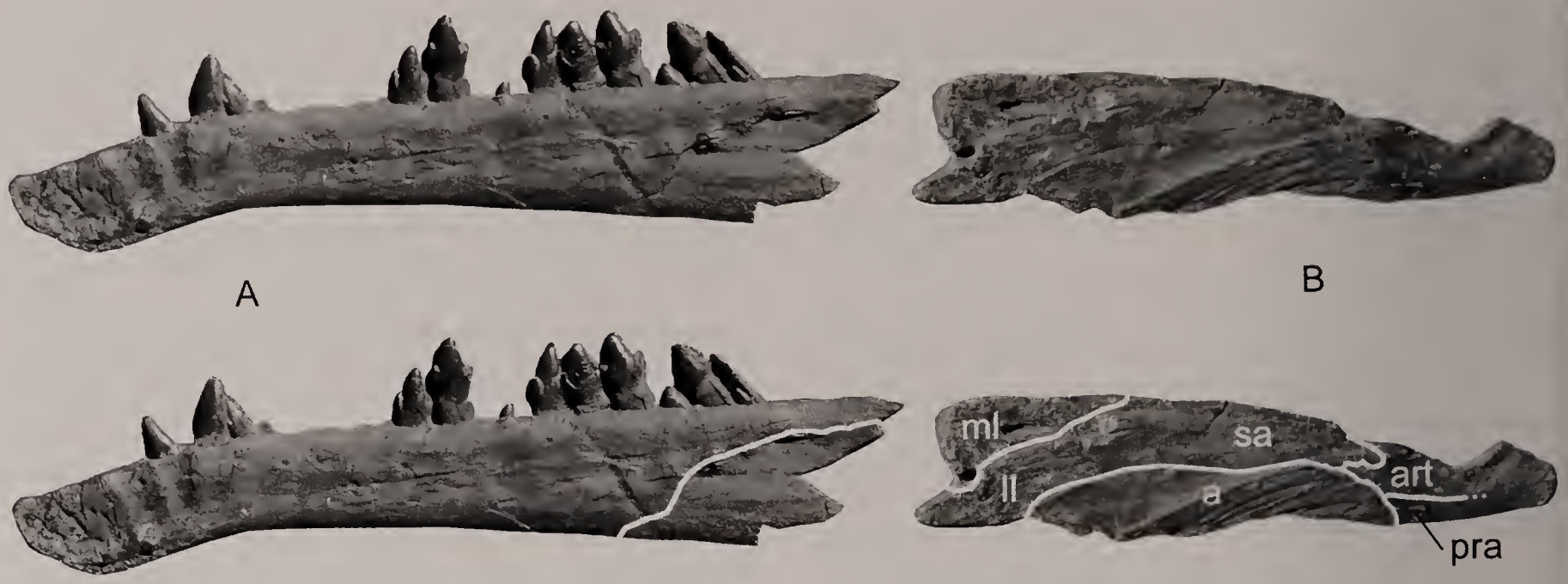

Fig. 51 – *Tanystropheus longobardicus*, PIMUZ T 2484, lower jaws. The best preserved dentary is shown in association with the best preserved post-dentary part of the lower jaw. A) Right dentary in lateral view, reflected horizontally. B) Post-dentary part of the left dentary in lateral view. Photo: Rosi Roth, PIMUZ.

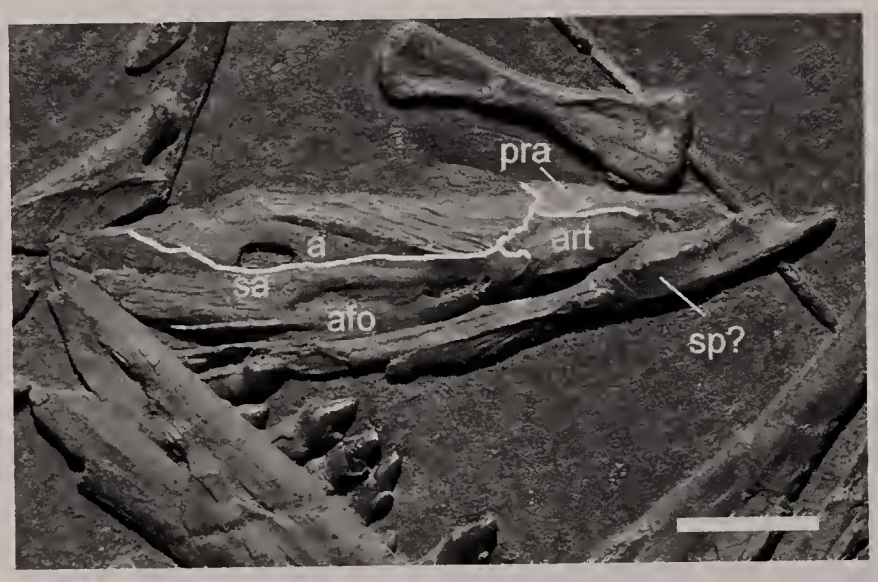

Fig. 52 – *Tanystropheus longobardicus*, PIMUZ T 2484, post-dentary part of the right lower jaw in medio-lateral view. Scale bar 5 mm. Photo: Rosi Roth, PIMUZ.

of the lower jaw there is a notch (Fig. 51). I assume that this notch accommodated the splenial, as stated by Wild (1974: fig. 16). Indeed, Wild found poor evidence for the shape of the splenial in the PIMUZ material. Based on the right lower jaw of MSNM BES SC 1018 (Fig. 53 B), I conclude that this element extended along the ventral margin of the lower jaw far more posteriorly than it was assumed by Wild (Figs. 49 A-B, 53). Evidence from MSNM BES SC 1018 also indicates that the isolated element close to the posterior part of the right lower jaw in PIMUZ T 2484 (Wild, 1974: fig. 15; Figs. 48, 52 in this paper), interpreted by Wild as a prearticular, is more probably a fragment of the splenial.

The nature of the contact between the surangular and the angular in lateral view cannot be inferred from the new specimens but it is clear in PIMUZ T 2484. In

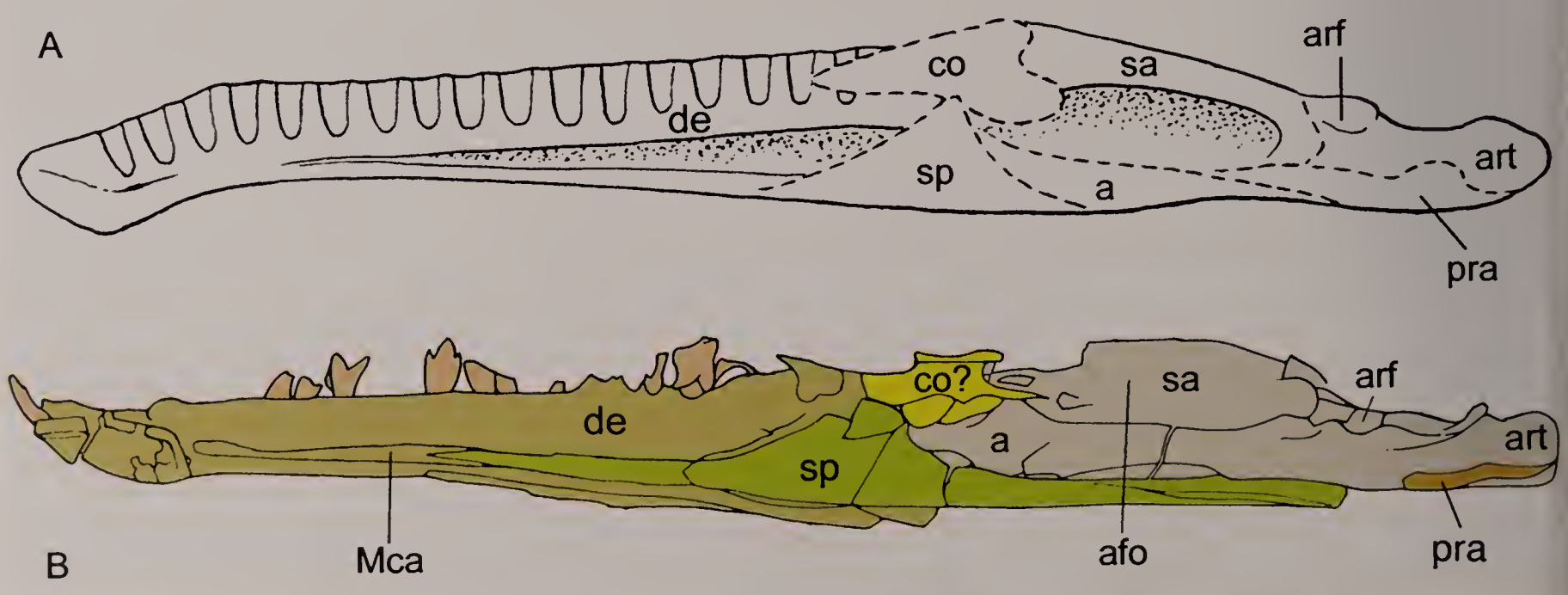

Fig. 53 – Lower jaw in medial view, in small-sized specimens of *Tanystropheus longobardicus*. A) Reconstruction of Wild (modified after Wild, 1974: fig. 16 b). B) Right mandibular ramus of MSNM BES SC 1018 as interpreted by the author, drawing: Massimo Demma.

both the left (Figs. 50, 51 B) and the right (Figs. 48, 52) isolated post-dentary parts of the lower jaws of this specimen I identified the suture between the two elements as an oblique, dorsally convex line, which is positioned more dorsally than assumed by Wild. In all probability, he identified as a suture the line delimiting a wide ventral area characterized by a striking sculptured surface for muscular attachment. This was probably for the insertion of the posteroventral 1b (superficialis layer of the external adductor) described by Rieppel & Gronowsky (1981), and assumed by these authors to be present also in *Macrocnemus* (Rieppel & Gronowsky, 1981: fig. 6 B), a taxon closely related to *Tanystropheus*.

Posteriorly, as can be seen more clearly in the isolated post-dentary part of the left lower jaw of PIMUZ T 2484 (Fig. 51 B), the surangular meets the articular in an interdigitating suture, and the angular meets both the articular and prearticular. The nature of the contact between the surangular, angular, and articular on the medial surface of the lower jaw in *Tanystropheus* remains elusive (Fig. 53 B).

In the left lower jaws of MSNM BES SC 265 and MSNM BES SC 1018 (Fig. 49 C-E) it is confirmed that the prearticular formed the posteriormost part of the ventral margin of the lower jaw without, however, completely underlying the retroarticular process. The prearticular is dorsally delimited from the articular by a straight or dorsally slightly concave suture (Figs. 49, 51-52). In MSNM BES SC 1018 there is evidence for the prearticular being exposed to a lesser extent than supposed by Wild on the medial surface of the lower jaw (Fig. 53).

The coronoid is an element difficult to identify in the material of *Tanystropheus*. Wild (1974: fig. 15, pl. 18; Fig. 48 in this paper) interpreted as the right coronoid in lateral view an isolated element of subtriangular shape in PIMUZ T 2484. This element has a distinct peduncle and an expanded portion entirely occupied by a concave articular facet. Wild (1974: 37, figs. 15-16; Fig. 53 A in this paper) interpreted the peduncle as directed posteriorly and ventrally and the coronoid probably overlapping the surangular, the dentary and the splenial. He also stated that "The slightly convex dorsal lamina of the coronoid rises only insignificantly above the dentary" (Wild, 1974: 37). This interpretation is difficult to understand. In my opinion there is no evidence of the peduncle being directed ventrally and posteriorly. I think that the only way to interpret the presumed coronoid of PIMUZ T 2484 is to suppose that the peduncle was directed dorsally and posteriorly, forming a rudimentary coronoid process, and that the concave facet on the expanded part of the bone was in contact with the medial surface of the lower jaw. Based on this interpretation, the presumed coronoid in PIMUZ T 2484 would be the left one in lateral view.

In the new specimens there is no clear evidence of the coronoid morphology. However, a rod-shaped element can be seen close to the dorsal margin of the mandible in the left lower jaw of MSNM BES SC 265 (Fig. 49 C). In the left lower jaw of MSNM BES SC 1018, an approximately rod-shaped but curved element that corresponds in position to the rod-shaped element of MSNM BES SC 265 is preserved (Fig. 49 E). A curved isolated element similar in shape and position to that observed in MSNM BES SC 1018 is also seen in *T. meridensis* (Fig. 49 G). This element was interpreted by Wild (1980a) as an ectopterygoid. Finally, on the right lower jaw of MSNM BES SC 1018 (Fig. 53 B), preserved in medial view, there is a distinct rod-shaped element similar to that observed in the left lower jaw of MSNM BES SC 265 and in the same position as all the others. In the right lower jaw of MSNM BES SC 1018 I tentatively identified as part of the coronoid also an area ventral to the rod-shaped element described above, which might correspond to the expanded part of the isolated bone interpreted by Wild as a coronoid in PIMUZ T 2484. The rod-shaped element observed in different specimens in lateral view might represent the peduncle of the same bone, forming a rudimentary coronoid process.

Dentition

As ascertained by Wild (1974), the dentigerous bones in the small-sized specimens of *Tanystropheus* are the premaxilla, the maxilla, the dentary, the pterygoid, the palatine and the vomer. This is fully confirmed by the new specimens, which also confirm the presence of anterior conical teeth and posterior tricuspid teeth in the upper and lower jaws.

Wild considered small-sized specimens to have five conical premaxillary teeth and the large-sized ones to have six (Wild, 1974: 47, fig. 80). However, on the basis of the new specimens there is no difference in the number of premaxillary teeth between small- and large-sized specimens of *Tanystropheus*. As the interpretation of the premaxillary dentition in MSNM BES SC 1018 is unequivocal, the premaxillary dentition was reconstructed on the basis of this specimen.

The left maxilla of MSNM BES SC 1018 bears 14 teeth, all ankylosed. Specimen MSNM BES SC 265 only has 12 tooth positions in the maxilla. The number of maxillary teeth documented by Wild in the small-sized specimens in the PIMUZ Collections was 11-13 (Wild, 1974: 47, fig. 80). As Wild counted 12 or possibly 14 maxillary teeth in the large-sized specimens, there is again no appreciable difference in the number of maxillary teeth in specimens of different size. While the 14 maxillary teeth in MSNM BES SC 1018 are all tricuspid, the anteriormost tricuspid maxillary tooth identified in MSNM BES SC 265 is the fourth (right maxilla). Wild considered the anteriormost maxillary teeth to be conical in the small-sized PIMUZ specimens (Wild, 1974: 47, fig. 80). It therefore seems likely that there is some variability but I based the reconstruction of the maxillary dentition on MSNM BES SC 1018, i.e. with 14 tricuspid teeth.

The left dentary of MSNM BES SC 1018 bears 19 teeth, with the anteriormost six conical, and the remaining ones tricuspid. In MSNM BES SC 265 the anteriormost preserved teeth are conical but the actual number of conical and tricuspid teeth, as well as the total number of dentary teeth, cannot be ascertained. Wild (1974: 47, fig. 80) stated that the small-sized specimens in the PIMUZ Collections have at least eight, or even 11, anterior conical teeth, followed by tricuspid teeth, for a total of 17-19 dentary teeth. Again,

there seems to be some variability but I reconstructed the dentary dentition based on MSNM BES SC 1018. If, as stated by Wild (1974: 47, fig. 80), the large-sized specimens in the PIMUZ Collections had 19-20? teeth on the dentary, there is no appreciable difference in the number of dentary teeth in specimens of different size. The conical teeth of the upper and the lower jaw are interlocking (Ford, 2002), while the tricuspid teeth of the upper jaw are positioned labial to the corresponding teeth of the lower jaw.

At least 12 tooth-attachment sites are present on the left pterygoid of MSNM BES SC 1018. Wild (1974: 13-14) counted 14 alveoli in the pterygoid of PIMUZ T 2484 (Fig. 43), but emphasized that this number is variable (he counted less than 13 alveoli in PIMUZ T 2482). No information can be given regarding the shape and size of pterygoid teeth based on the new specimens. According to Wild (1974: 13, 48) the pterygoid teeth were all conical and forming a shagreen-like dentition.

The elements identified as the left and the right palatine in MSNM BES SC 1018 each bear four large alveoli. Wild (1974: 48) counted five large alveoli plus a smaller one in the small-sized specimens in the PIMUZ Collections. He reported no palatine teeth preserved in situ in the PIMUZ specimens but mentioned an isolated conical tooth in PIMUZ T 2484 with a basal diameter matching the size of the palatine alveoli (Wild, 1974: fig. 24 e). This tooth is similar in shape to the palatine tooth tentatively identified in MSNM BES 265 (p. 11).

In both MSNM BES SC 1018 and MSNM BES SC 265 only isolated vomerine teeth were identified. According to Wild (1974: 47-48) the total number of vomerine teeth in the small-sized PIMUZ specimens is 9-12. The tiny vomerine teeth identified in the new small-sized specimens are similar in shape to those described by Wild (1974: fig. 24 d). The same is true for the vomerine teeth of the large-sized MSNM V 3663 (p. 38, Fig. 31), some of which are preserved still in situ. Based on this specimen the vomer bore at least ten alveoli.

The axial skeleton: an overall description

(Figs. 1, 4-8, 14-20, 30, 33-34, 54-60, Pls. I-IV, Tabs. 2-3)

As emphasized by Wild (1974: 52), the remarkable compression and/or incomplete preservation of the vertebral column in the *T. longobardicus* material from the *Grenzbitumenzone* (=Besano Formation) hampers the detailed reconstruction of vertebral morphology. Specimens MSNM BES SC 265 and MSNM BES SC 1018 support Wild's statement and some crucial issues, such as the precise orientation of the zygapophyseal articular facets, remain elusive. Thus, as pointed out by Wild (1974: 52), examination of *T. longobardicus* specimens is of little value for understanding the functional morphology of the vertebral column, particularly of the cervical series. On the other hand, Wild (1974: 67-94, figs. 39-62) did describe in detail some isolated, three-dimensionally preserved vertebrae of *T. conspicuus* from the Upper Muschelkalk of Bayreuth. It was on this material that he based his arguments for the mobility of the vertebral column and the posture of the neck. Maintaining that the vertebrae of *T. conspicuus* were very similar to those of *T. longobardicus*, Wild (1974: 52) argued that the same conclusions could be applied to both species and reconstructed the vertebrae of *Tanystropheus* based on *T. conspicuus* (Wild, 1974: fig. 38).

As discussed below, the vertebral morphology in the new specimens of *T. longobardicus* is similar to but not exactly the same as *T. conspicuus*. Moreover, differences in vertebral morphology can be observed between smaller- and larger-sized individuals of *T. longobardicus* in the PIMUZ Collections. Interestingly, Dalla Vecchia (2006) recently described isolated, three-dimensionally preserved vertebrae of *Tanystropheus* cf. *longobardicus* from the Middle Triassic of northern Friuli (Italy). These vertebrae belong to large-sized individuals and some of their features are different from those described for the new specimens. These differences in vertebral morphology might alternatively represent ontogenetic variation within the same taxon or taxonomic variation in separate species, and can be evaluated only with a complete revision of the genus *Tanystropheus*. On one hand, *T. longobardicus* and *T. conspicuus* might be synonymous (Wild, 1980b: 204; 1987: 39), while the small- and large-sized *T. longobardicus* specimens in the PIMUZ Collections might represent two separate taxa (Fraser *et al.*, 2004).

Cervical vertebrae and ribs

(Figs. 1, 7, 14, 30, 34, 54-59, Pls. I-IV, Tab. 2)

All *T. longobardicus* specimens, those described here included, confirm that the cervical vertebral column comprises 12 vertebrae (Wild, 1974: 50, although 13 cervicals were represented by Wild in pl. 1).

The cervical vertebrae three through ten are typically extremely elongate and slender, and the increase in centrum length is not concomitant with an increase in height.

The length/height ratio can be estimated taking the measurement for height at the middle of the centrum, where the neural spine is absent or weakly developed as a low keel. In the new specimens, the centra of cervical vertebrae three through ten are at least nine times as long as the height of the vertebra at the middle of the centrum. The highest ratios occur in cervicals eight and nine, with centra 13-15 times as long as the vertebral height.

In Fig. 54 the pattern of vertebral lengthening along the cervical column in MSNM BES SC 265, MSNM BES SC 1018 and in the PIMUZ specimens is compared by plotting the ratios "length of cervical vertebrae two (axis) through twelve / length of the axis". The pattern obtained is similar for the new specimens and those in the PIMUZ Collections, irrespective of the overall size of the individual specimens. As stated by Wild (1974: fig. 29), there is a peak of vertebral lengthening between the second and third cervical vertebrae. After a further, yet moderate, increase in length between the third and fourth vertebrae, vertebral lengthening is negligible between the fourth and sixth vertebrae. A gradual, yet continuous, increase in length is observed again between the sixth and ninth vertebrae, the latter being the longest (with the single excep-

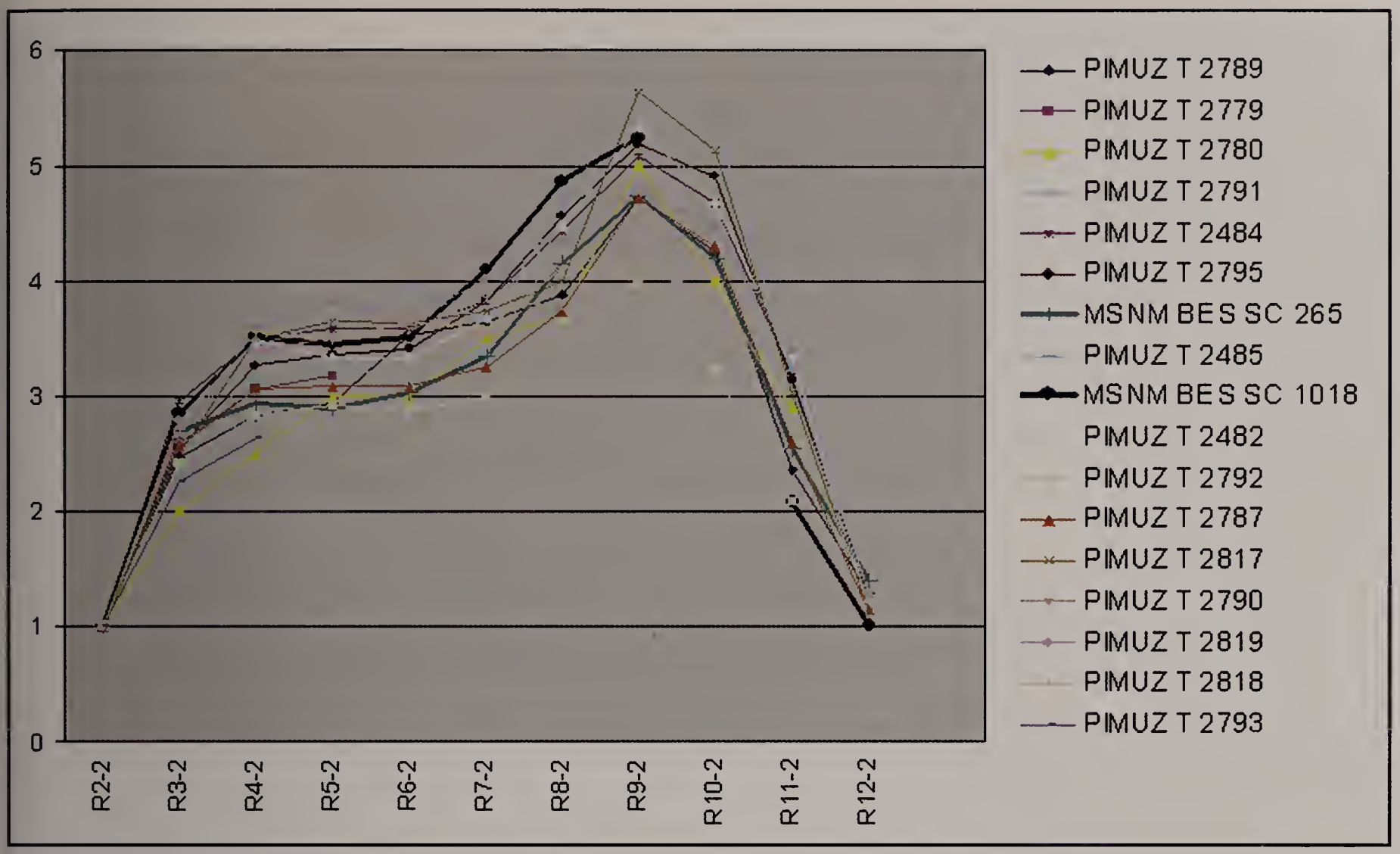

Fig. 54 – Ratios "length of cervical vertebrae two (axis) through twelve/length of the axis" in *Tanystropheus longobardicus* (measurements for the PIMUZ specimens after Wild, 1974: tab. 3). The specimens are listed from the smallest-sized one to the largest-sized one.

tion of PIMUZ T 2818). Posterior to the ninth vertebra, the trend is reversed, with the vertebral length slightly decreasing in the tenth vertebra relative to the ninth, and very steeply so between the tenth and the 12th.

Wild (1974: 52) stated that with increasing age (=overall length) of the individuals the difference in length between the eighth, ninth and tenth cervical vertebrae becomes smaller and smaller but this is apparently only true for PIMUZ T 2818, in which cervical vertebrae eight through ten reach very similar lengths, the eighth being the longest. Wild (1974: 52) also maintained that in specimens over 2 meters overall length (i.e. his "adult" individuals) the mutual rate of lengthening of the cervical vertebrae changes. In particular, with increasing overall length, the difference in length of vertebrae four through ten would decrease, because of the positive allometric growth in the third and fourth vertebrae, and slower or no additional growth in the ninth vertebra. However, Wild's statement is not confirmed by the pattern shown in Fig. 54, which shows instead that the mutual rate of lengthening of the cervical vertebrae is not affected by the overall length of the specimens. I think that the pattern of lengthening of the cervical vertebrae in specimens of different overall length does not contradict the hypothesis that small- and large-sized specimens of *Tanystropheus* represent different ontogenetic stages of the same species. However, contra Wild (1974: 52), I do not think that it supports the hypothesis either.

Both in the PIMUZ material and in the new specimens the atlas is never preserved as a complete element. The atlas-axis complex of *T. longobardicus* was reconstructed by Wild (1974: fig. 31) on the basis of the large-sized specimen PIMUZ T 2819 (Fig. 55). This specimen preserves the paired neural arches of the atlas, and other isolated elements interpreted by Wild as the proatlas, the atlas centrum, and the atlas intercentrum (Wild, 1974: fig. 6, pl. 16). The right atlas neural arch of PIMUZ T 2819 is very similar in shape to the left atlas neural arch of MSNM BES SC 1018 (Figs. 10-12, 56 B). Both are exposed in lateral view. The neural arch is an L-shaped element with a posterior and a ventral ramus. In PIMUZ T 2819 the posterior ramus is more developed than the ventral one, while in MSNM BES SC 1018 the two rami approximately reach the same length. The postzygapophysis takes the form of a rib-shaped, horizontal relief projecting backwards from the posterior ramus of the neural arch. According to Wild (1974: 55, fig. 31), the neural arch projected anteriorly into a pointed process, the *cornu atlanticum* but the presence of this process on the left atlas neural arch of PIMUZ T 2819 is not clear. By contrast, I assume that the right atlas neural arch of MSNM BES SC 1018 is articulated anteriorly with the proatlas (Figs. 10-12). Based on this assumption it is unlikely that the two isolated elements interpreted by Wild as the proatlas in PIMUZ T 2819 (Fig. 55) were correctly identified. As an alternative I suggest that the element labelled "pa?" in Fig. 55 and partially overlapped by the left quadrate is the proatlas in articulation with the right atlas neural arch. Wild considered this fragment of bone to be part of the left quadrate. I do concur with Wild on the identification of the atlas centrum and intercentrum in PIMUZ T 2819 (see also Figs. 10-12).

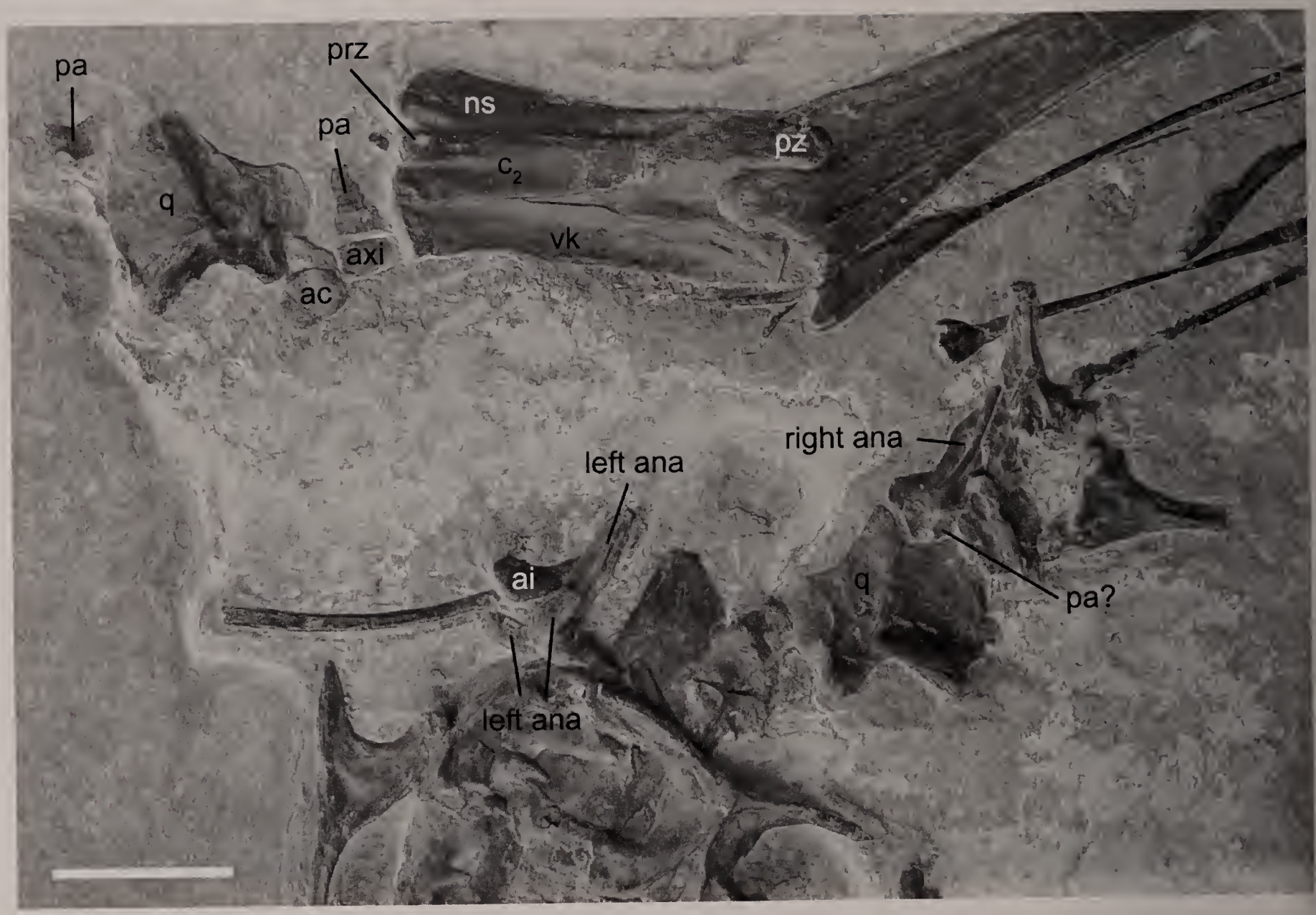

Fig. 55 – *Tanystropheus longobardicus*, PIMUZ T 2819, atlas and axis on the interpretation of Wild, 1974. pa?: proatlas on the interpretation of the author. Scale bar 20 mm. Photo: Heinz Lanz, PIMUZ.

The morphology of the axis is well documented in the known material of *Tanystropheus*, and is apparently the same in both small- and large-sized specimens (Wild, 1974: figs. 30-31). The reconstruction given by Wild (1974: fig. 31), based on the large-sized PIMUZ T 2819 (Fig. 55), is consistent with the new specimens (Fig. 56). Apart from the atlas, the axis is invariably the shortest vertebra of the cervical column. The articular surfaces of the centrum are not inclined. The anterior surface is ventrally bevelled, receiving an elongate intercentrum. A latero-ventral margin (*die Lateroventralkante* or *margo inferior*, *sensu* Tschanz, 1986: 60) running along the entire length of the centrum delimits a well developed ventral keel (=hypapophysis *sensu* Wild, 1974: 55). As in the subsequent cervicals (see below), the latero-ventral margin bifurcates anteriorly into two sharp cristae for the rib articulation. As compared to that of the subsequent cervicals, the neural arch of the axis is well developed, raising anteriorly into a rounded neural spine. It has an anterior tubercle for the insertion of the atlanto-occipital ligaments (Wild, 1974: 56; Fig. 56 A in this paper). The prezygapophyses are apparently short and stocky (Wild, 1974: fig. 31) and do not project beyond the anterior end of the centrum. According to Wild (1974: 56), they originally had horizontal articular surfaces but this cannot be verified in the new specimens. The articular relationship between the atlas neural arch and the axis, as interpreted by Wild (1974: fig. 31), is confirmed by MSNM BES SC 265 (p. 13, Fig. 56 A). An articular facet at the basis of the axis neural arch, as seen in PIMUZ T 2819 (Fig. 55) probably received the atlas neural arch. The postzygapophyses of the axis are elongate and project beyond the posterior end of the centrum.

The morphology of cervicals three through ten is similar in the new specimens, and it is particularly clear in the more three-dimensionally preserved vertebrae of MSNM BES SC 1018. The anterior and posterior articular surfaces of the centra are not inclined. By contrast, Wild (1974: 95) ascertained that in *T. conspicuus* these surfaces are inclined anteriorly to a variable degree. As is typical for *Tanystropheus*, strongly keeled margins run along the centrum (Wild, 1974; Tschanz, 1985, 1986). However, a latero-dorsal margin (*die Laterodorsalkante* or *margo lateralis*, *sensu* Tschanz, 1986: 61) running along the entire length of the centrum and continuing onto the dorsal margins of the pre- and the post-zygapophysis was not observed in the new specimens. The neural spine is poorly developed.

The third and fourth cervicals of MSNM BES SC 1018 (Fig. 57 A) have a strongly keeled latero-ventral margin running along the entire length of the centrum, approximately at its half-height. On this basis the cross section in the middle of the centrum would have been sub-circular. The latero-ventral margin is posteriorly bifid. Anteriorly it bifurcates into two sharp cristae separated by a groove, for the rib articulation. This latter feature is very distinct also in the cervical vertebrae of MSNM BES SC 265 (Fig. 58).

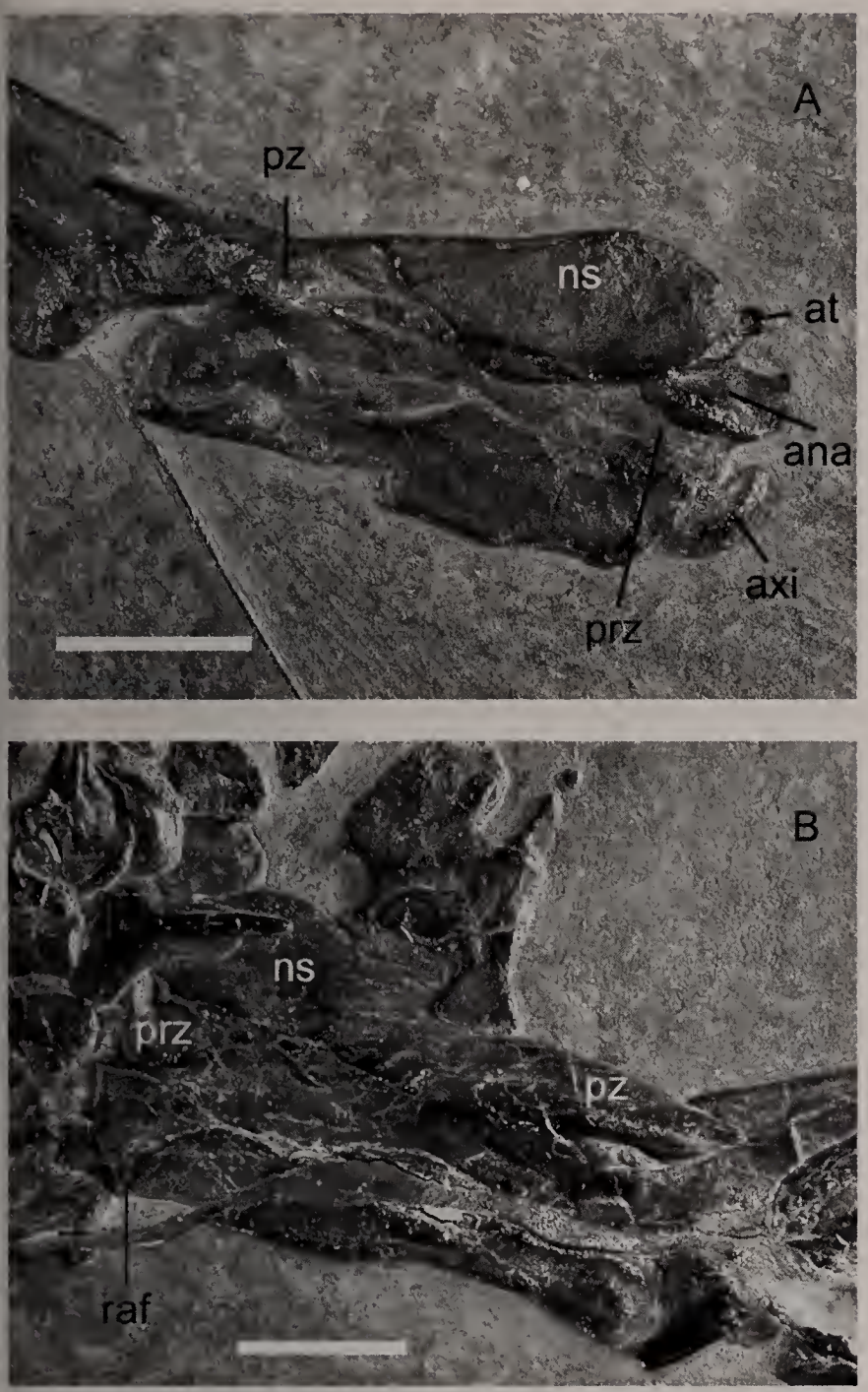

Fig. 56 – *Tanystropheus longobardicus*, axis. A) MSNM BES SC 265, right lateral view. Scale bar 5 mm. B) MSNM BES SC 1018, left lateral view. Scale bar 5 mm. Photos: Massimo Demma.

The dorsal crista continues onto the ventral margin of the prezygapophysis. A keeled ventral margin (*die Ventralkante* or *margo ventralis*, *sensu* Tschanz, 1986: 59) was probably not developed in these vertebrae. The neural spine is only anteriorly developed in the third cervical, where it consists of a low ridge projecting into a pointed tip rising up from the dorsal surface of the centrum. In the fourth cervical it is rudimentarily developed also posteriorly. Anteriorly, the neural spine bears a sharply pointed process, and ventral to it is a sub-triangular fossa bordered by raised margins.

In MSNM BES SC 1018, posterior to the fourth cervical, the raised latero-ventral margin runs along the centrum from the prezygapophysis, becoming lateral to the flat ventral surface of the centrum, and levels out in its posterior part (Tschanz, 1986: 60) (Fig. 57 B). On this basis the cross section in the middle of the centrum would have been sub-triangular (Tschanz, 1986: 60). A ventral keel seems to be developed anteriorly in cervicals eight through ten. In cervicals five through ten the neural spine extends along the entire length of the centrum as a continuous, yet very low, dorsal keel, which becomes higher anteriorly and posteriorly (Fig. 57 B).

In the specimens of *T. longobardicus* of the PIMUZ Collections Wild (1974: 58) observed that from the sixth-seventh cervical on backwards the neural spine grows significantly higher anteriorly and is gradually reduced posteriorly. In cervicals three through ten of the larger specimens a dorsal keel is absent, and the neural spine is almost completely reduced posteriorly (Tschanz, 1986: 62). A neural spine only anteriorly developed was described by Dalla Vecchia for the large, three-dimensionally preserved cervical MFSN 31579 (*T.* cf. *longobardicus*, Dalla Vecchia, 2006: fig. 8), tentatively identified as the ninth (Dalla Vecchia, 2006: fig. 17). Dalla Vecchia suggested that this feature might be an apomorphy indicating that the new material from Friuli represents a new species of *Tanystropheus*.

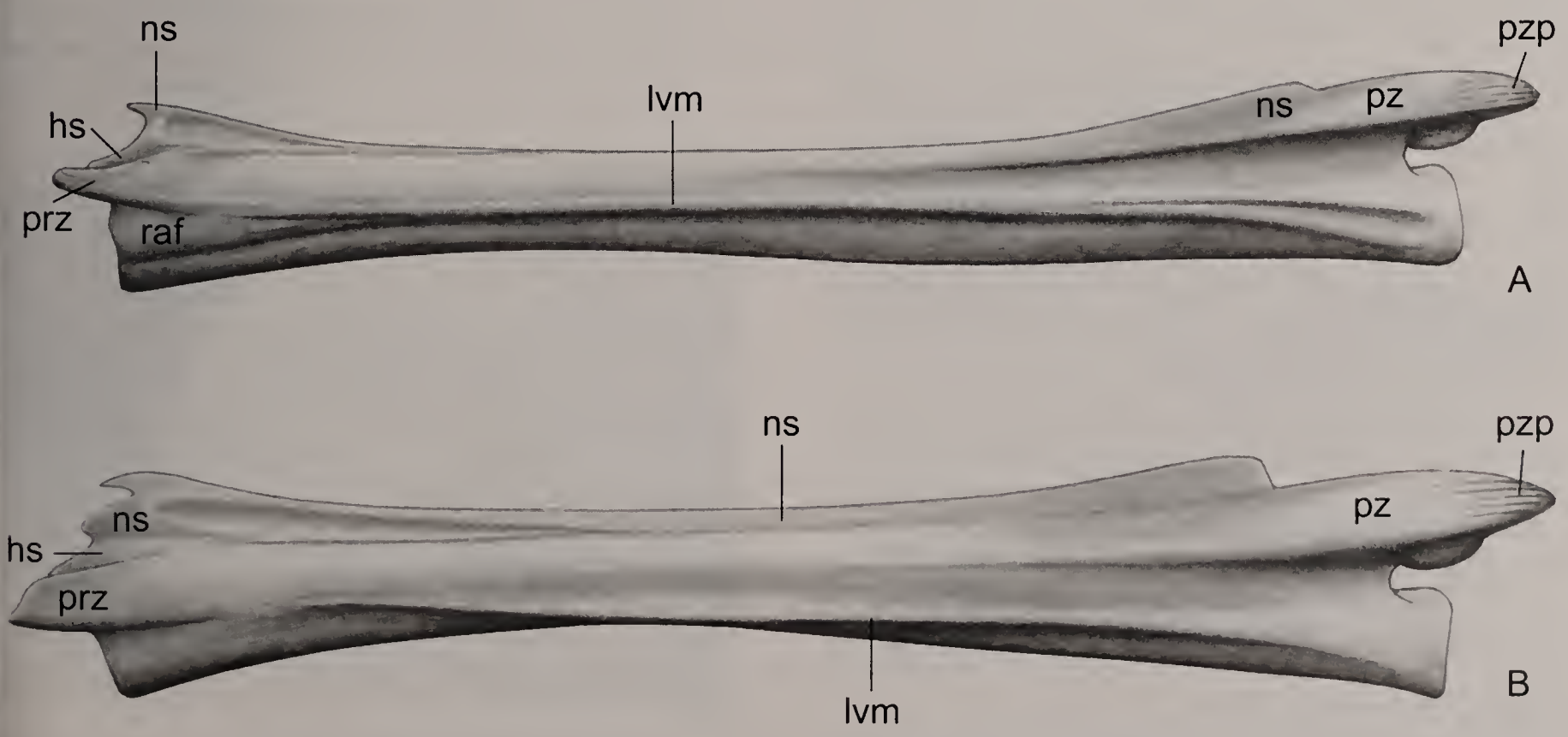

Fig. 57 – Reconstruction of an anterior cervical vertebra (A) and of a mid-cervical vertebra (B) in small-sized specimens of *Tanystropheus longobardicus*. Left lateral view. Not to scale. Watercolor: Massimo Demma.

Fig. 58 – *Tanystropheus longobardicus*, MSNM BES SC 265, articulation between the fifth and sixth cervical vertebrae. Scale bar 5 mm. Photo: Massimo Demma.

Both pre- and postzygapophyses of the cervical vertebrae three through ten project well beyond the anterior and posterior ends of the centrum. A strongly keeled margin delimits the postzygapophysis ventro-laterally, extending anteriorly up to approximately one half the length of the centrum. In MSNM BES SC 1018 the postzygapophyses have a finely striated surface for muscular insertion (*die Intertransversal-Muskulatur*, Wild, 1974: 58).

In MSNM BES SC 265 and MSNM BES SC 1018, the 11th vertebra (Fig. 14) is similar in its general shape to that figured by Wild (1974) in fig. 97 a (PIMUZ T 1270). The centrum is remarkably shorter than that of the preceding cervicals, and the neural arch higher, yet not as high as in the corresponding cervical of *T. conspicuus* (Wild, 1974: fig. 97 b-c). The anterior and posterior articular surfaces of the centrum are not inclined. Two distinct facets for the rib articulation are borne on two tubercles positioned antero-ventrally on the centrum and separated by a groove. A latero-ventral margin runs from the dorsal tubercle along approximately three-fourths of the centrum, delimiting a ventral keel. Both pre- and postzygapophyses project beyond the articular surfaces of the centrum. The neural spine runs along the entire length of the centrum as a low keel, raising anteriorly and posteriorly, so that the outline of the neural spine in lateral view is concave. As is also the case in the preceding cervicals, the neural spine deepens anteriorly into a sub-triangular fossa bordered by raised margins.

In MSNM BES SC 265 (Figs. 4, 7) the 12th cervical is very short, the length of its centrum only slightly exceeding that of the axis (Tab. 2). Albeit damaged, its neural arch is clearly much higher than in the preceding cervicals. As emphasized by Renesto (2005), the posterior articular surface of the centrum is antero-posteriorly inclined. Similar to the 11th vertebra, two antero-ventral tubercles separated by a groove bear distinct facets for the rib. A latero-ventral margin runs from the dorsal tubercle along almost the entire length of the centrum, delimiting a ventral keel. By contrast with the postzygapophyses, the prezygapophyses project only very slightly beyond the anterior end of the centrum. This features are consistent with the description given by Wild (1974: 80, fig. 50) for the 12th cervical of *T. conspicuus*.

Little can be added to our understanding of the articulation of the cervical vertebrae on the basis of the new specimens. As expected, the prezygapophyses are dorsally overlapped by the postzygapophyses. Observation of the disarticulated vertebrae four and five in MSNM BES SC 1018 (Fig. 59) reveals that the postzygapophyseal articular facet was probably sub-vertical in this region. The postzygapophyseal articular facet of the fourth cervical has an oval, antero-posteriorly elongate shape and is positioned ventral and medial to the postzygapophyseal process (*sensu* Rieppel, 2001). The latter projects posteriorly beyond the articular facet, roofing it, and in the articulated vertebrae would lie on a sub-horizontal shelf borne on the prezygapophysis. This shelf is seen on the fifth cervical, medial to the dorso-lateral margin of the prezygapophysis.

In the large, three-dimensionally preserved cervical MFSN 31579 (Dalla Vecchia, 2006: 37, fig. 8) the postzigapophyseal facets slant in a dorso-lateral/ventro-medial plane, forming an angle of 45° with the medial plane of symmetry. The prezygapophyseal facets appear to be vertical in MFSN 31579 but they face dorso-medially in other cervicals comprised in the material studied by Dalla Vecchia (2006: 37-38).

In both MSNM BES SC 265 and MSNM BES SC 1018, the cervical ribs clump in tight, paired bundles ventral to the cervical column. Both specimens do not add new information on the well-known morphology of the cervical ribs in *Tanystropheus*. The head of each rib in dorsal view is axe-shaped, with an anterior and posterior process. The latter is present also in the anteriormost cervical ribs.

Wild (1974: 98) emphasized that the articular facets for the ribs borne on the centrum are different between *T. conspicuus* and *T. longobardicus*. He described the

Fig. 59 – *Tanystropheus longobardicus*, MSNM BES SC 1018, articulation between the fourth and fifth cervical vertebrae. Scale bar 5 mm. Photo: Massimo Demma.

articular facets of the latter as elliptical and positioned in grooves. According to Wild (1974: 59) the tuberculum and capitulum in the first eight ribs posteriorly formed a single synapophysial articular surface, these ribs thus being functionally olocephalous. This cannot be confirmed in the new specimens. However, an isolated rib head preserved close to the tenth cervical vertebra in MSNM BES SC 1018 exhibits a completely separated tuberculum and capitulum. The 11th cervical of the same specimen unequivocally has two articular facets for the rib (Fig. 14), as do the 11th and 12th cervicals in MSNM BES SC 265 (Figs. 4, 7). In the latter specimen, the tuberculum and capitulum of the 12th cervical rib are distinctly shorter and higher, as is typical of a dichocephalous rib (Fig. 4).

In the specimens described here, as mentioned above, the tuberculum and capitulum of the functionally holocephalous ribs articulate on two divergent crests - separated by a deepened triangular surface - positioned ventro-laterally on the centrum. In MSNM BES SC 265, this feature is clearly seen in vertebrae of the series two through seven (Fig. 58 A). In MSNM BES SC 1018, it can be clearly seen in the third and fourth vertebrae. In the sixth vertebra the articulation of the rib with the centrum is apparently more ventral. In fact, moving posteriorly there seems to be a progressive ventral shift in the position of the rib articulation. The articular area on the centrum in the mid- and posterior cervicals cannot be described on the basis of MSNM BES SC 1018.

The extremely thin and elongate shafts of the cervical ribs are closely packed in MSNM BES SC 265, and it is difficult to ascertain either their length or number in the different regions of the cervical vertebral column. The same is true for MSNM BES SC 1018, in which the shafts of the cervical ribs are also extensively broken. In MSNM BES SC 265 one of the fourth ribs is isolated, and its shaft apparently intact. Its length exceeds that of three cervical vertebrae.

Dorsal vertebrae and ribs
(Figs. 1, 4-5, 7, 15-18, 20, 33, 60, Pls. I-IV)

All the known specimens confirm that the dorsal vertebral column of *T. longobardicus* consists of 13 vertebrae. However, Wild (1974) distinguished 11 dorsal vertebrae and two "lumbar" vertebrae. Indeed, the morphology of the last two dorsals is different from that of the preceding ones (see bolow).

Wild (1974) described the dorsal vertebrae in *T. longobardicus* on the basis of the large-sized specimen PIMUZ T 2817 and the smaller PIMUZ T 1270. He maintained that in the other specimens in the PIMUZ Collections these vertebrae were too badly crushed to permit a reconstruction.

Common features of the dorsal vertebrae are the ventrally concave centra and tall neural spines, as compared to those of the cervical vertebrae. The neural spines are dorsally flattened and reinforced by a stout, rough ridge for muscular insertion.

The dorsal vertebrae can be grouped into an anteriormost region, comprising vertebrae one through three; an intermediate region, comprising vertebrae five through ten; and a posterior or "lumbar" region comprising the last two dorsals. The fourth and 11th dorsal vertebrae cannot be clearly assigned to anyone of these regions (see below).

In Fig. 60 A the anteriormost dorsal vertebrae are reconstructed on the basis of MSNM BES SC 265 (Fig. 4) and MSNM BES SC 1018 (Fig. 16). The height measured from the ventral surface of the centrum to the top of the neural spine is approximately equal to the length of the centrum. The centrum is deeply concave and keeled ventrally. The posterior articular surface slants anteroposteriorly. Typically, the anteriormost dorsal vertebrae bear two articular facets for dichocephalous ribs. The wide, sub-circular articular facet for the capitulum of the rib is borne on a distinct tubercle positioned ventrally and anteriorly on the centrum. A rounded articular facet for the tuberculum is borne on a stout but short transverse process. The transverse process is positioned on the anterior half of the centrum, where the neural arch is fused to the centrum but is somewhat more ventral

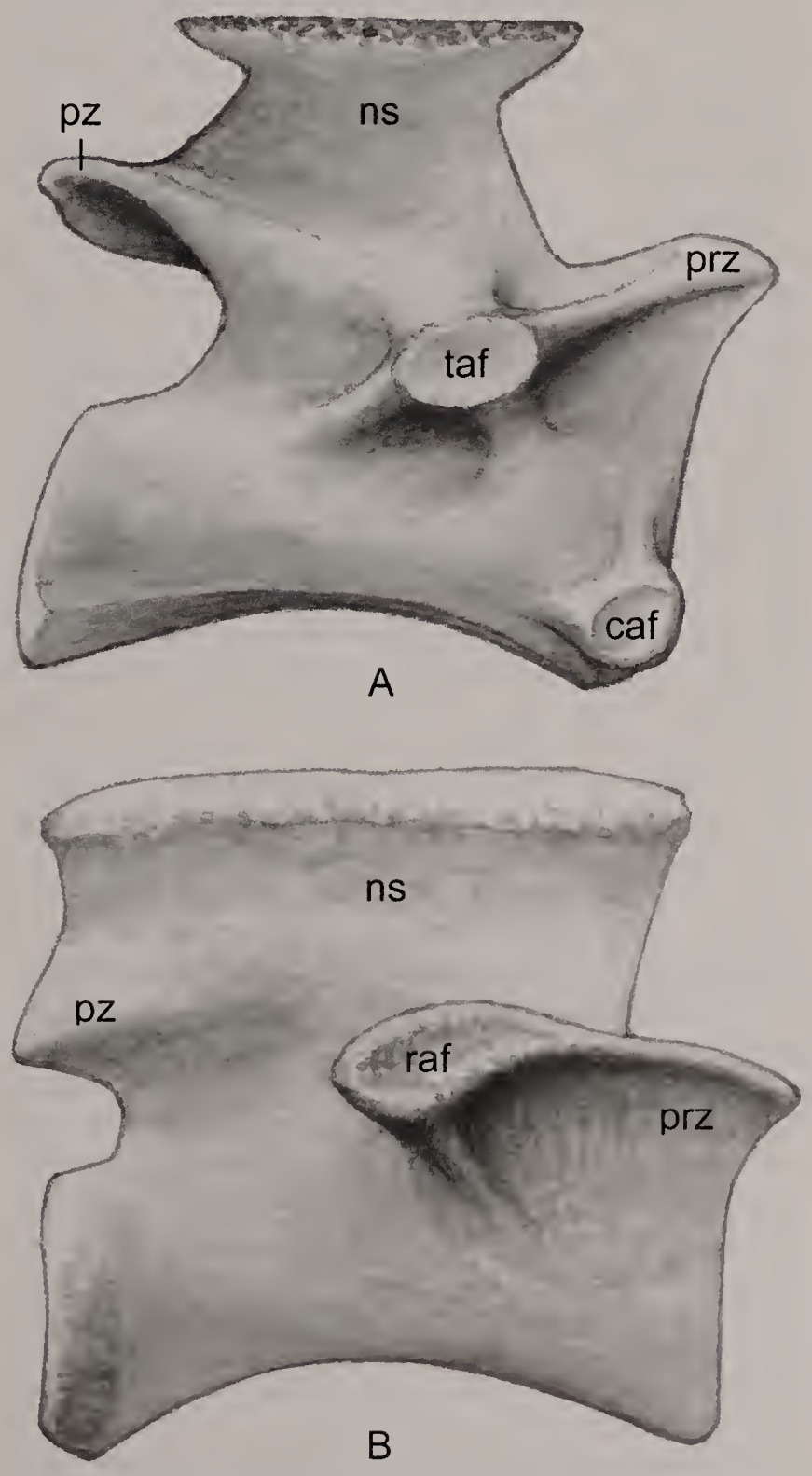

Fig. 60 – Reconstruction of an anteriormost dorsal vertebra (A) and of a mid-dorsal (B) in small-sized specimens of *Tanystropheus longobardicus*. Right lateral view. Not to scale. Watercolor: Massimo Demma.

in the first dorsal. A stout bony bridge extends between the transverse process and the prezygapophysis. A short buttress supports the transverse process ventrally, both anteriorly and posteriorly. This arrangement is similar to that described by Wild (1974: 61) for the first five dorsals in *T. longobardicus*. The prezygapophyses are short and project dorsally and only slightly beyond the anterior end of the centrum. The postzygapophyses are located high on the neural arch, separated from the centrum by a deep notch. They do not project beyond the posterior end of the centrum. The orientation of the zygapophyseal articular facets is sub-vertical. The neural spine takes the form of a truncated pyramid, with anteriorly and posteriorly projecting processes at the top and a flat dorsal surface. It is approximately as long as tall.

The morphology of the anteriormost dorsal vertebrae in MSNM BES SC 265, MSNM BES SC 1018, and the small-sized *T. longobardicus* specimens in the PIMUZ Collections (Peyer, 1931: pls. 1-3) differs from that reconstructed by Wild (1974: figs. 38 c, 52) for *T. conspicuus*. In the latter species, the height of the anteriormost dorsals, measured from the ventral surface of the centrum to the top of the neural spine, is approximately twice the length of the centrum. The neural spines are sub-rectangular in shape and taller than long (Renesto, 2005: 378).

The centrum of the mid-dorsal vertebrae (Fig. 60 B) is poorly preserved both in MSNM BES SC 265 (Fig. 7) and MSNM BES SC 1018 (Figs. 15, 20) but on the basis of the material in the PIMUZ Collections it is ventrally concave (see also Renesto, 2005: fig. 4; Dalla Vecchia, 2006: fig. 10). The length of the centrum is equal to or exceeds the height measured from the ventral surface of the centrum to the top of the neural spine. Neither the anterior nor posterior articular surfaces of the centrum are inclined. The single, sub-oval articular facet for an holocephalous rib is borne on a short transverse process. However, it might look shorter than it really was since the specimens have been greatly crushed (see for comparison specimen MCSN 4451, Renesto, 2005: fig. 4 A). The transverse process is positioned close to the base of the neural arch, approximately mid way along the centrum. A short, ridged buttress supports the transverse process antero-ventrally (centrodiapophyseal lamina *sensu* Dalla Vecchia, 2006). Short prezygapophyses, positioned at the same level as the transverse processes, project very slightly beyond the end of the centrum. The lateral margin of each prezygapophysis takes the form of a laterally projecting crest reaching the transverse process posteriorly (Figs. 15, 20, 60 B). The postzygapophyses are located low on the neural arch and project only slightly beyond the end of the centrum. The orientation of the zygapophyseal articular facets is interpreted as sub-horizontal (see also Tschanz, 1985: 174). The neural spines are sub-rectangular and approximately twice as long as tall (Renesto, 2005: 378).

The morphology of the mid-dorsals of the new specimens from Besano is thus different in some respects from that of the mid-dorsals of *T. conspicuus* (Wild, 1974: figs. 38 d-e, 54) and of other large-sized specimens of *Tanystropheus* such as PIMUZ T 2818 (*T. longobardicus*, Wild, 1974: pl. 13) and MFSN 31596 (*T.* cf. *longobardicus*, Dalla Vecchia, 2006: fig. 10). In these large dorsals the height measured from the ventral surface of the centrum to the top of the neural spine is twice or more the length of the centrum. The neural spine is antero-posteriorly short and approximately as long as tall. This was linked by Wild (1974: 61) to the need for larger and higher insertion areas for the musculature in the large-sized individuals. A diapoprezygapophyseal lamina (*sensu* Dalla Vecchia, 2006) runs obliquely from the transverse process on the lateral side of the prezygapophysis. The transverse process is rather high on the neural arch. Specimen MFSN 31596 has quite long and dorso-ventrally flattened transverse processes with antero-posteriorly expanded ends, which according to Dalla Vecchia (2006: 43) might be an apomorphy of the taxon represented by the material from Friuli.

Specimen MSNM BES 215 described here (pp. 38-39) also represents a large-sized individual. The short postzygapophyses, positioned low on the neural arch and provided with sub-horizontal articular facets, suggest that this vertebra is in all probability a mid-dorsal. As in MSNM BES SC 265 and MSNM BES SC 1018, the transverse process projects laterally from the area where the neural arch meets the centrum. By contrast, although the neural spine of MSNM BES 215 is broken, the height of its preserved part suggests that it was very tall. Finally, this dorsal vertebra is unique for all known *Tanystropheus* material for the presence of postzygapophyseals canals in the postzygapophyseal trough. Wild (1974: 81) described a deep postzygapophyseal trough (*die postzygapophyseale Grube*) and postzygapophyseal canals (*der Doppelkanal*; *das Röhrenpaar sensu* von Meyer, 1847-1855) in the cervical vertebrae of *T. conspicuus*. Rieppel (2001) described a similar feature in the cervical vertebrae of *T. haasi*. In this species, postzygapophyseal grooves in the floor of the postzygapophyseal trough extend far anteriorly into the neural arch, separated from one another by a thin vertical bony septum, and separated from the neural canal by an equally thin horizontal septum. As formerly pointed out by Wild (1974: 81) the postzygapophyseal canals end blindly. Wild (1974: 81) stated that a postzygapophyseal trough could be seen also in the dorsal, lumbar and caudal vertebrae of *Tanystropheus*. However, postzygapophyseal canals have been never described in the post-cervical vertebrae.

Based on the small-sized *Tanystropheus* specimen MCSN 4451 Renesto (2005: fig. 4) assumed that the nature of the rib articulation changes gradually along the dorsal vertebral series and described an intermediate condition in which two articular facets for the rib are very close to each other but still not confluent. Specimen MSNM BES SC 265 unequivocally shows that from the fifth dorsal on backwards there is a single articular facet for the rib, borne on the transverse process. A close look at MCSN 4451 reveals that the ventral articular facet on the vertebra figured by Renesto (2005) in fig. 4 A is in fact an artefact of fossilization, and that there is but a single articular facet for the rib. I was not able to confirm the presence of two articular facets close to each other in the vertebra figured by Renesto (2005) in fig. 4 B. Indeed the vertebra is badly crushed and difficult to interpret. In MSNM BES SC 265 the fourth dorsal is very poorly preserved. However, as far as can be judged from the morphology of the transverse process and prezygapophysis, it has a single articular facet for the rib just like all subsequent dorsals. By contrast, on the basis of specimens PIMUZ T 2817 and PIMUZ T 2787, Wild (1974)

considered the fourth dorsal had two articular facets for the rib, while from the fifth on there was a single articular facet. An intermediate condition similar to that described by Renesto (2005) for MCSN 4451 might be present in an isolated dorsal of MSNM BES SC 1018, that I tentatively interpret as the fourth (Fig. 17). The strongly concave and keeled centrum, the antero-dorsally projecting prezygapophysis, and the shape of the neural spine are typical characters of the anteriormost dorsal vertebrae. By contrast, the postzygapophysis is very similar in shape to that of the subsequent dorsals, probably bearing a sub-horizontal articular facet. This vertebra has an unequivocal single articular facet for the rib on the transverse process, with a stout, oblique, and distinctly projecting crest extending between the transverse process and the prezygapophysis. Another crest extends from the transverse process to the antero-ventral area of the centrum. Along this crest there may be a second articular facet. If this is the case, this vertebra has two facets for the rib articulation showing a condition similar to that described by Renesto (2005). I conclude that there is individual variation in the position of the facets for the rib articulation on the anteriormost dorsal vertebrae. However, as a rule the mid-dorsal vertebrae typically have a single facet borne on the transverse process.

The morphology of the 11th dorsal vertebra is different from both preceding and subsequent vertebrae. Although this vertebra is not well preserved in MSNM BES SC 265 (Fig. 5), it is very similar to an isolated, well preserved vertebra in MSNM BES SC 1018 (Fig. 18). The centrum of the 11th dorsal bears a single, wide, roundish facet for the rib articulation borne on a stout and short transverse process. The transverse process is positioned very close to the prezygapophysis at the base of the neural arch. Both anteriorly and posteriorly, the transverse process is supported by short ventral buttresses. The anterior buttress is strongly ridged. The prezygapophysis is shaped as in the mid-dorsal vertebrae, with a presumed sub-horizontal articular facet. The postzygapophysis is positioned high on the neural arch, and in shape is more like the anteriormost dorsals than the mid-dorsals.

Dorsal vertebrae 12 and 13 ("lumbar vertebrae"), are poorly preserved in MSNM BES SC 265 (Fig. 5) but are strikingly different from the preceding ones. The neural spine is square and distinctly shorter than in the mid-dorsals. The postzygapophysis is positioned high on the neural arch. Finally, these vertebrae bear long pleurapophyses[1].

In both MSNM BES SC 265 and MSNM BES SC 1018, the dorsal ribs are mostly disarticulated and scattered, and many of them are missing alltogether. Observation of the preserved elements suggests that the morphology of the dorsal ribs in the new specimens is similar to that described by Wild (1974: 63, fig. 35). In MSNM BES SC 265, the first dorsal rib is preserved in association with the first dorsal vertebra (Fig. 4). The tuberculum is short and thick, the capitulum is longer and more slender. The shaft is distally overlapped by the second dorsal vertebra so that its full length cannot be ascertained. An anteriormost, isolated dichocephalous rib is also preserved in MSNM BES SC 1018 (p. 28), which is shaped like the first dorsal rib of MSNM BES SC 265. Its shaft does not seem broken, although it appears rather short. The second dorsal rib is not preserved in MSNM BES SC 265 but the third is. It is not completely articulated with the third vertebra but the tuberculum and the capitulum lie very close to the corresponding vertebral articular facets. This rib is slender with a short tuberculum and a longer capitulum. The shaft is gently curved. In the new specimens it is not possible to ascertain whether the fourth dorsal rib was still dichocephalous but on the basis of the morphology of the fourth dorsal vertebra in MSNM BES SC 265 (see above) it probably was not.

Sacral vertebrae
(Figs. 1, 6, 8, 19, Pls. I-IV)

The sacral vertebrae are readily identified based on their expanded pleurapophyses[1] that articulated with the ilium. Specimen MSNM BES SC 265 (Figs. 6, 8) confirms that there are two sacral vertebrae in *Tanystropheus*. The isolated sacral vertebra preserved in MSNM BES SC 1018 (Fig. 19) is interesting, because it displays the vertebra in lateral view. In MSNM BES SC 1018, the overall shape of the vertebra is quite different from that of the sacral vertebrae described by Wild for *T. longobardicus* (Wild, 1974: 62) and *T. conspicuus* (Wild, 1974: figs. 55, 56, tab. 6). These display a shorter, less slender centrum and a tall, sub-rectangular and antero-posteriorly short neural spine. A large, three-dimensionally preserved sacral vertebra referred to *Tanystropheus* cf. *longobardicus* (MFSN 31552) was recently described by Dalla Vecchia (2006: fig. 11). It does not preserve the neural spine but the centrum is very similar to that of the sacrals in *T. conspicuus*.

Caudal vertebrae
(Figs. 1, 6, Pls. I-IV, Tab. 3)

The description of the caudal vertebrae is based on MSNM BES SC 265, which preserves the caudal series in its original proximo-distal sequence (Figs. 1, 6). The isolated caudals in MSNM BES SC 1018 do not add relevant information and neither specimen provides any real detail of the caudals distal to the 11th (Fig. 1, Pls. I-IV).

The centra of the first three caudal vertebrae are approximately as long as those of the second and the 11th dorsal vertebrae. The length of the subsequent centra steadily increases proceeding distally along the caudal series (Tab. 3). Up to the eight vertebra, the centra are

[1] Wild (1974: 62) used the term "pleurapophysis" to indicate a rib fused to the transverse process. As emphasized by Romer (1956: 276), once a rib is completely fused to the transverse process without a discernible suture between the two, it is difficult to establish whether it represents a rib fused to the transverse process or an elongate transverse process. Both Renesto S. (pers. comm., 2006) and I observed that there is sometimes a line of separation visible at the very base of the wall of the neural arch, without even a short transverse process (see for example the third caudal in MSNM BES SC 265). However, it is difficult to tell whether it is a suture or a fracture. In the absence of additional arguments clarifying this issue, I will adopt the term "pleurapophysis" as used by Wild.

strongly concave ventrally. Caudals one through seven have well developed latero-ventral margins, delimiting a ventral keel in the sixth and seventh. The articular surfaces of the centra are not inclined.

The first neural arch that can be observed is that of the sixth caudal. The neural spine is lower than in the mid-dorsals, and dorsally flattened. Distal to the sixth vertebra, the neural spine progressively shortens and shifts posteriorly. The pre- and postzygapophyses lie at approximately the same level. The prezygapophyses project well beyond the anterior end of the centrum, while the postzygapophyses are shorter, extending only to approximately the posterior end of the centrum. A crest connects the pre- and postzygapophyses on the lateral side of the neural arch. This crest is very well developed in vertebrae seven through nine but reduced in the tenth vertebra and almost absent in the 11th. The zygapophyseal articular surfaces appear sub-horizontal (see also Tschanz, 1985: 174; Dalla Vecchia, 2000: fig. 2; 2006: fig. 12).

In MSNM BES SC 265, the first through eighth caudals display pleurapophyses (see note on p. 69), that increasing in length from the first to the third element in the caudal series. The pleurapophyses of the fourth and fifth caudals are broken and cannot be measured. A fragment of one such pleurapophyses (Pl. II) suggests that they were still rather long. Distal to the fifth vertebra, the length of the pleurapophyses is significantly reduced. In the eighth caudal the pleurapophysis is rudimentary, and there are no pleurapophyses on the subsequent caudals. The number of caudal vertebrae with more or less well developed pleurapophyses is therefore consistent with the number given by Wild (1974: 62) of seven-eight for the small-sized specimens of *T. longobardicus*. As pointed out by Wild, the position of the pleurapophysis on the centrum shifts diagonally ventrally and posteriorly proceeding distally along the caudal series. The pleurapophyses of the proximal caudal vertebrae are stoutly built (see also the proximal caudals in MSNM BES SC 1018, Pls. III-IV), as shown by their wide antero-posterior base, and they are strongly dorso-ventrally flattened.

None of the preserved caudal vertebrae in the new specimens is similar in shape to the proximal caudals of *T. conspicuus* (Wild, 1974: figs. 38 f, 57-61). The latter possess very tall and antero-posteriorly short, sub-rectangular neural spine. The postzygapophysis is very short and apparently bears an oblique articular facet. However, given the rather poor preservation of caudals one through five in MSNM BES SC 265 and of the proximal isolated caudals in MSNM BES SC 1018, the overall shape of these vertebrae cannot be described and compared to the specimens in the PIMUZ Collections. The shape of the sixth caudal vertebra in MSNM BES SC 265, and of those distal to it, is more like that of the mid-caudal vertebra of *T. conspicuus* in Wild's fig. 62. Dalla Vecchia (2000: fig. 2, MFSN 25761; 2006: fig. 12, MFSN 31549) described proximal isolated caudal vertebrae of *Tanystropheus* from the Middle Triassic of northern Italy, belonging to rather large individuals. The shape of the neural spine of these vertebrae is also similar to that described by Wild for the proximal caudals of *T. conspicuus*.

The first preserved chevron in MSNM BES SC 265 is that between the seventh and eighth vertebrae, and the last between the 11th and the 12th. As stated by Wild (1974: 67, fig. 37), the shape of the chevrons changes moving distally down the vertebral series. Their ventral rami become shorter, and antero-posteriorly expanded in lateral view. An isolated chevron is preserved in MSNM BES SC 1018 (p. 29, Pls. III-IV), showing that the two branches of the chevrons meet ventrally, forming a median spine, and are dorsally connected by a transverse bar in a condition slightly different from that shown in Wild's (1974) fig. 67.

In MSNM BES SC 265, the vertebral series distal to the 11th caudal vertebra is complete but it cannot be ascertained how many vertebrae are present. On the basis of its length (p. 15), the series apparently comprises a minimum of 30 vertebrae of a length comparable with that of the proximal caudals but this number was surely far higher if the progressive shortening of the centra towards the tip of the tail is taken into account. In fact, the estimated length of the distalmost caudal vertebrae of MSNM BES SC 265 is 2.5 mm. Unfortunately, the caudal series is not complete and poorly preserved in MSNM BES SC 1018. According to Wild (1974: 62), the overall number of caudal vertebrae was over 50.

The presence of fracture planes indicative of caudal autotomy (Wild, 1974: 94) cannot be confirmed on the caudal vertebrae of MSNM BES SC 265.

The mobility of the vertebral column in *Tanystropheus*

The description of the pre- and postzygapophyseal articular facets in the three-dimensionally preserved vertebrae of *T. conspicuus* (Wild, 1974: 96-98) remains the best starting point for any understanding of the mobility of the vertebral column in *Tanystropheus*.

At present, the only detailed descriptions and interpretations of the axial locomotory system in *Tanystropheus* are those of Wild (1974) and Tschanz (1985; 1986; 1988). These authors, however, came to different conclusions.

Analysing the shape and the orientation of the zygapophyseal facets, and evaluating the role played by the very thin and elongate cervical ribs in the mechanics of the cervical vertebral column, Wild (1974) asserted that the neck of *Tanystropheus* was very mobile and, when on land, could assume an S-shaped configuration. Wild recognized three distinct regions in the neck. In the anterior region, he considered sagittal movements predominated but with some lateral flexion. In the mid-region, sagittal flexion predominated, while in the caudal region both sagittal and lateral flexion were possible.

Wild (1974) also stated that, compared to the cervical series, the mobility of the dorsal and caudal series was less. He assumed that the anteriormost dorsal column had the capability to flex dorsally and laterally but proceeding posteriorly towards the sacral region the overall mobility of the dorsal vertebral column decreased. In the caudal region as a whole he considered dorsiflexion to be reduced and to be absent alltogether in the proximal caudals. From the mid-caudal region on, Wild thought that sagittal and lateral movements of the tail were possible. However, according to Wild, the overall mobility of the tail did not suggest that it was used for propulsion.

By contrast, Tschanz (1985; 1986; 1988) gave a different interpretation of the morphology described by Wild and postulated that the neck of *Tanystropheus* had little mobility. On the other hand, Tschanz thought that there was reasonable lateral movement in both the trunk and tail.

Gastralia
(Pls. I-IV)

Only a few elements are preserved in MSNM BES SC 265 and while the majority are present in MSNM BES SC 1018, it is difficult to determine their precise number and arrangement. In the anteriormost gastral rows two medial elements meet along the midline. They form an angle, with the vertex facing anteriorly. They are thicker medially and taper laterally into pointed ends. These elements appear longer than those in the reconstruction of Wild (1974: fig. 36). Additional elements are thinner, curved, and pointed at both ends. They possibly represent the lateral elements described by Wild. Wild counted 25 gastral rows but judging from MSNM BES SC 1018, this number might have been higher.

Could *Tanystropheus* walk?

The pes in *Tanystropheus*

The new specimens offer remarkable new information on the morphology of the pes in *Tanystropheus*.

The reconstruction of the tarsus is largely based on the perfectly articulated tarsus of MSNM V 3730 (Figs. 35, 61) and the disarticulated, yet perfectly preserved elements in MSNM BES SC 1018 (Fig. 62).

The tarsus of *Tanystropheus* comprises four ossified elements. The calcaneum has a polygonal, laterally rounded shape with thickened lateral margin. Brinkman (1981: 7) claimed the presence of a "laterally directed dorsoventrally compressed tuber on the calcaneum" in *Tanystropheus*. However, there is neither a *processus lateralis* (*sensu* Schaeffer, 1941: 442) or a lateral, archosauromorph-like calcaneal tuber. The astragalus is an elongate element with an oblique orientation. The astragalus and calcaneum meet along a straight line. Their mutual mobility was precluded, and the two elements can be considered as a single unit (Wild, 1974: 118). In some *Tanystropheus* specimens, such as MSNM BES SC 265 (Fig. 65) and PIMUZ T 2480 (Fig. 63), the astragalus has a proximal lateral process overlapping or indenting with the calcaneum. However, *Tanystropheus* does not show the diagnostic features of a complex concave-convex articulation between the astragalus and the calcaneum (contra Brinkman, 1981: 7).

Dorsally and distally, as previously noted by Wild (1974) in the partially articulated tarsus of PIMUZ T 2480 (Fig. 63) and confirmed by MSNM BES SC 1018

Fig. 62 – *Tanystropheus longobardicus*, MSNM BES SC 1018, left pes in plantar view, particular of the tarsus. The astragalus and calcaneum are exposed in dorsal view. I-V = metatarsals. Scale bar 5 mm. Photo: Massimo Demma.

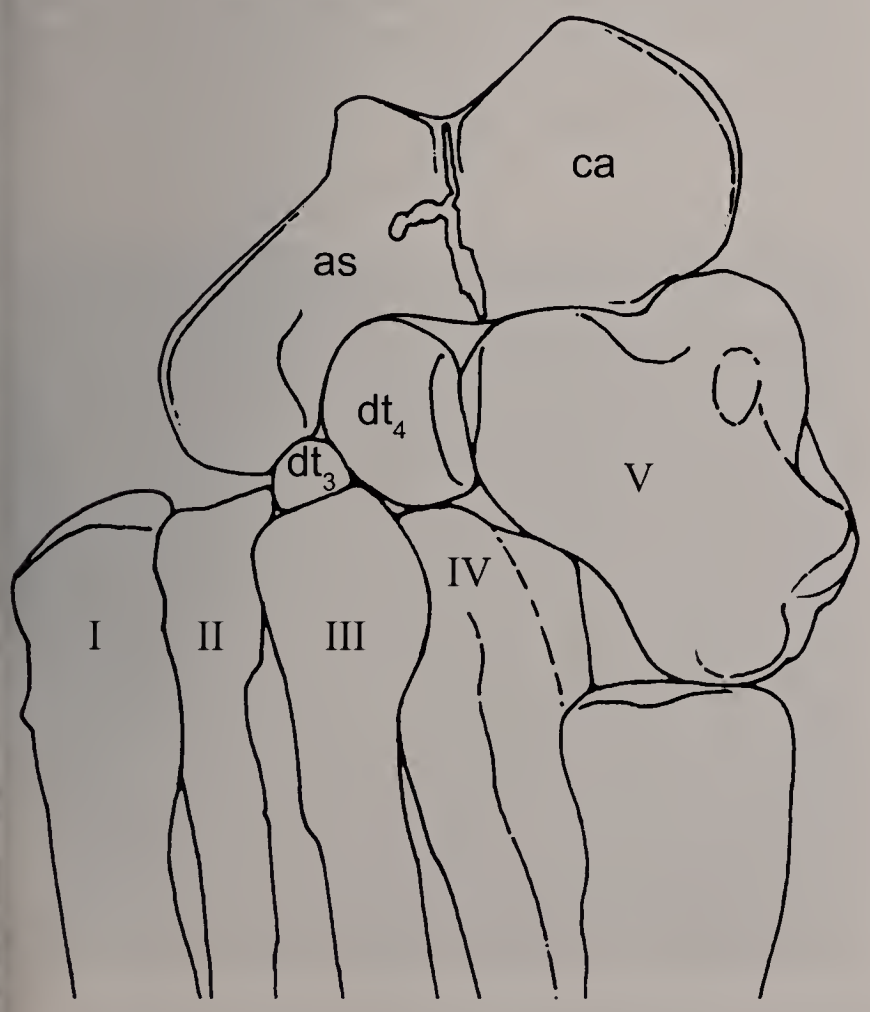

Fig. 61 – *Tanystropheus* cf. *longobardicus*, MSNM V 3730, right tarsus in plantar view. I-V = metatarsals. Drawing: Massimo Demma.

Fig. 63 – *Tanystropheus longobardicus*, PIMUZ T 2480, right tarsus in dorsal view. Scale bar 5 mm. Photo: Heinz Lanz, PIMUZ.

(Fig. 62), the astragalus and calcaneum both contribute to an embayment, in which the astragalus receives distal tarsal four, and the calcaneum receives metatarsal V. In MSNM V 3730 (Figs. 35, 61) the tarsus is exposed in plantar view (p. 42). Medially, the astragalus is recessed into a shallow fossa, like in the left tarsus of MSNM BES SC 265 (p. 19). However, an embayment formed by the astragalus and calcaneum proximally delimited by a sharp margin cannot be seen. At the same time, distal tarsal four and metatarsal V are not overlapped by the astragalus and the calcaneum. Consequently, distal tarsal four and metatarsal V must have possessed rounded proximal articular heads mirroring the concavity of the embayment (Fig. 64). The presence of a hinge-like mesotarsal joint in *Tanystropheus* is thus confirmed (Wild, 1974, after Kuhn-Schnyder, 1960). Wild thought that the presence of a mesotarsal joint was one of the characters indicative of lepidosaurian affinities. However, the mesotarsal joint in *Tanystropheus* is quite different from that observed in the extant squamates, in which the astragalocalcaneum and the distal tarsals have a complex, highly specialized morphology, permitting rotatory movements of the crus on the pes, as well as flexion-extension (Rewcastle, 1980). The fourth ossified element of the tarsus, distal tarsal three, is positioned medial to distal tarsal four, between the astragalus, proximally, and metatarsal III, distally.

I ascertained that the specimen of *Tanystropheus* recently described by Renesto (2005: pl. 2 H) corresponds to the description given above with respect to the shape of the tarsal elements and the nature of their articulation.

The morphology of the tarsus in MSNM BES SC 265 (p. 19, Figs. 9, 65), preserved in plantar view, looks different from MSNM BES SC 1018 (Fig. 62) and MSNM V 3730 (Figs. 35, 61), and is more difficult to interpret. The astragalus appears to have a slightly different shape and is not obliquely oriented within the tarsus. The articular relationships of distal tarsal three and distal tarsal four with the astragalus and calcaneum, and between each other, remain unclear.

Wild (1974: 118) conjectured that the tarsus of *Tanystropheus* originally comprised elements that were not ossified. This cannot be confirmed on the basis of the new material. However, in MSNM BES SC 265 the region medial to the astragalus is difficult to interpret: it neither looks like bone nor matrix (Fig. 65, Pl. I). It is possible that it represents a chondrogenic focus or a film of organic matter, indicative of the potential for chondrification of the centrale. Indeed, in other protorosaurs, including *Langobardisaurus* and *Macrocnemus*, the area distal and/or medial to the astragalus is occupied by an ossified centrale (Fig. 66). In MSNM BES SC 265 there is an undoubted gap medial and distal to the astragalus. The same gap is present in the perfectly articulated tarsus of MSNM V 3730. I suggest that this gap is indicative of a cartilaginous element keeping the metatarsals separate from the astragalus and providing some flexibility and elasticity for the medial area of the tarsus. In some plesiosaur limbs there is also indication of the presence of elements which apparently do not ossify (Forrest R., pers. comm., 2007).

In the well preserved specimens described here, metatarsals I-IV are tightly packed, their proximal ends overlapping partly. In MSNM V 3730 (Figs. 35, 61) an obliquely oriented articular facet is visible on metatarsal IV, suggesting that metatarsal V overlapped it. If similar articular facets were present on all the metatarsals, relative movements of the metatarsals could not be lateral, as stated by Wild (1974: 118) but must mostly have been dorso-plantar. In other words, mutual movements of the metatarsals would have resulted in an arched, ventrally concave metatarsus, rather than in a spreading of the foot due to abduction of the digits.

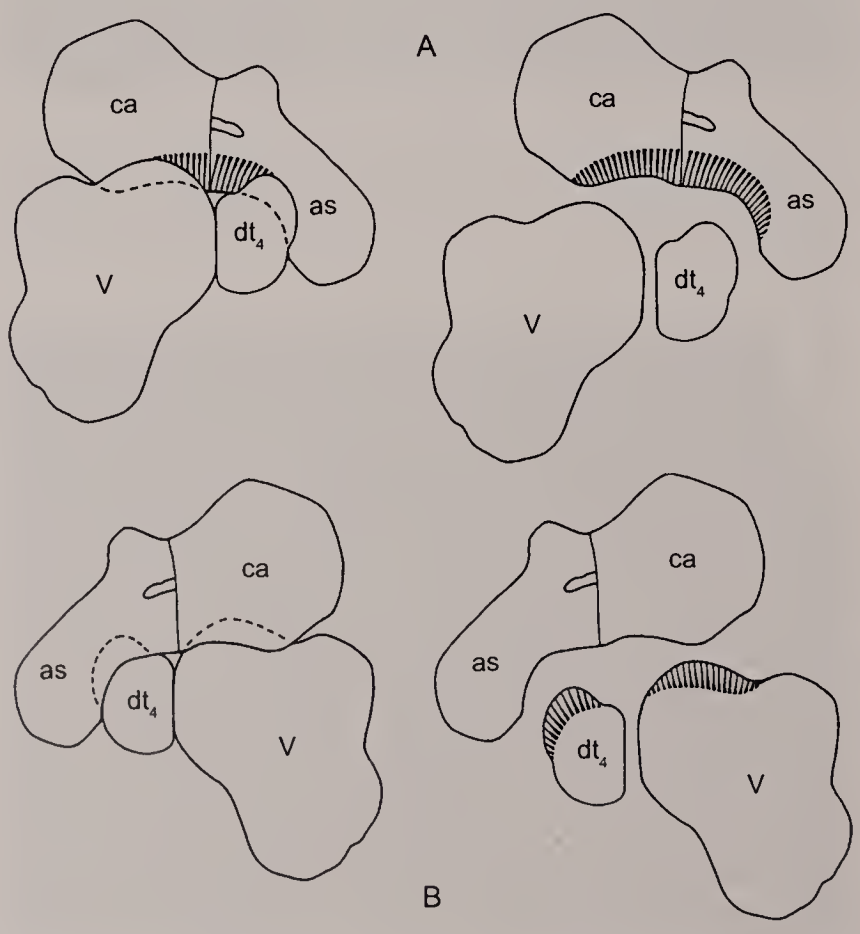

Fig. 64 – Reconstruction of the tarsus in small-sized specimens of *Tanystropheus longobardicus*. A) in dorsal view; B) in plantar view. Drawing: Massimo Demma.

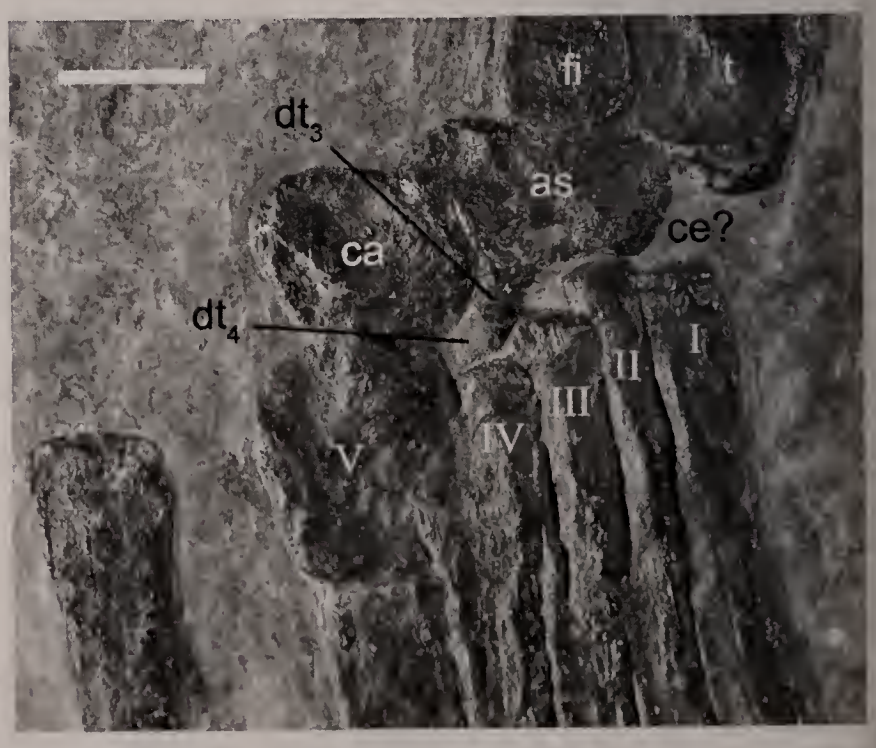

Fig. 65 – *Tanystropheus longobardicus*, MSNM BES SC 265, left tarsus in plantar view. I-V = metatarsals. Scale bar 5 mm. Photo: Massimo Demma.

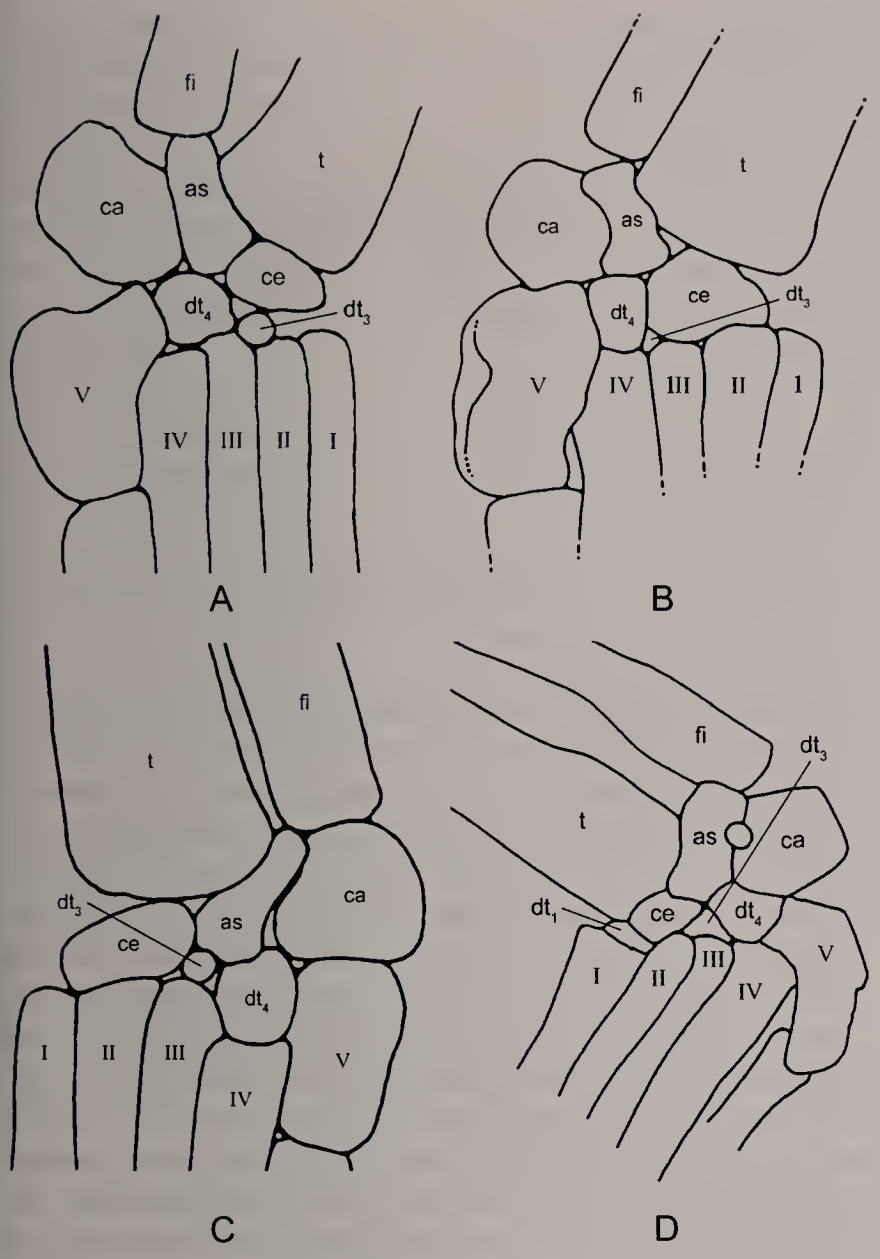

Fig. 66 – A) *Langobardisaurus tonelloi* (MFSN 1921), left pes in plantar view, redrawn after Renesto *et al.*, 2002: fig. 5 B. B) *Langobardisaurus pandolfii* (MCSNB 2883), left tarsus in plantar view, redrawn after Renesto, 1994: fig. 7. C) *Langobardisaurus pandolfii* (MCSNB 2883), right tarsus in plantar view, redrawn after Renesto, 1994: fig. 8 B. D) *Macrocnemus bassanii* (PIMUZ T AIII/208), left tarsus in dorsal view, redrawn after Rieppel, 1989: fig. 8 f. Not to scale.

The morphology of metatarsal V (in plantar view) is best seen in MSNM V 3730 (see description on p. 42; Figs. 35, 61). Metatarsal V is generally described, in *Tanystropheus* and its sister-taxa, as "hooked" (Olsen, 1979; Jalil, 1998; Renesto & Avanzini, 2002; Renesto *et al.*, 2002). The use of this term has been quite subjective over the years, as recently discussed by Rieppel *et al.* (2003: 370). "Hooking" of metatarsal V in *Tanystropheus* refers only to the fact that the roundish proximal head of metatarsal V articulates both with the calcaneum, proximally, and distal tarsal four, medially. A rounded process lateral to the distal end of metatarsal V might represent a lateral plantar tubercle for the insertion of the gastrocnemius muscle (Robinson, 1975; Brinkman, 1980; Rieppel, 1989; Renesto *et al.*, 2002). In addition, an "outer process" (*sensu* Robinson, 1975) with a distinct tuberosity is developed proximo-laterally. This might represent the same process described by Rieppel (1989) for *Macrocnemus*, for the possible insertion of muscles involved in the rotation of the foot.

The phalangeal formula of the pes in *Tanystropheus* (Tab. 9) is primitive. The first phalanx of digit five takes the form of a metatarsal.

The hindlimb: terrestrial versus aquatic locomotion

Once it was ascertained that *Tanystropheus* was not a flying reptile, as originally hypothesized by Bassani (1886) and von Nopcsa (1923), Peyer (1931) interpreted *Tanystropheus* as a lizard-like, terrestrial reptile.

Later, Wild (1974) suggested a terrestrial habit for the juveniles but a predominantly aquatic habit for the adults. Wild considered the hindlimb to be the primary organ for locomotion in water, mainly because of a paddle-shaped, webbed foot. According to Wild, skeletal correlates for aquatic adaptation were the wide sites for the insertion of adductor and retractor limb musculature on the ischium and the femur, the elongation of the metatarsus, and the presence on the metatarsals of oblique articular facets permitting the digits to be spread. Wild suggested that digit five, in particular, had great lateral mobility, and because of its long, metatarsal-like first phalanx, it contributed to a large extent to the distal widening of the surface of the supposed webbed foot. At the same time, Wild considered *Tanystropheus* to be capable of moving on land as an adult, although he did not explain how in any detail. In essence, he envisaged a lizard-like gait, in which the mesotarsal joint in the tarsus of *Tanystropheus* played a role that is substantially similar to the function of the same joint in extant squamates (Rewcastle, 1980). Following Kuhn-Schnyder (1960), Wild (1974: 109-110, 142) thought that the forelimb was used not only for locomotion on land but also for digging. Putative skeletal correlates for this adaptation were an alleged shortened and wide manus with thickened phalanges and strong claws (but see p. 33).

Interpretations of *Tanystropheus* as a fully aquatic reptile emphasized the role of the hindlimb in supporting aquatic locomotion (Tschanz, 1985; 1986), or as the main organ of propulsion in water (Taylor, 1989). However, Renesto (2005) recently questioned an aquatic mode of life for *Tanystropheus* and discussed the morphology of the limbs. According to Renesto (2005: 388), the architecture of the hindlimb is completely different from that of any appendage-propelled aquatic vertebrate and lacks any evident adaptation for swimming in open waters. He maintained that the hindlimb was the main propulsive force in locomotion in *Tanystropheus*, because the forelimb is relatively very short and the carpus poorly ossified. In fact, forelimbs considerably shorter than the hindlimbs is an archosauromorph feature shared by *Tanystropheus* with the relatively well known protorosaurian taxa *Langobardisaurus* (Renesto *et al.*, 2002) and *Macrocnemus* (Rieppel, 1989), and with the poorly described *Tanytrachelos* (Olsen, 1979) and *Cosesaurus* (Ellenberger, 1977; Sanz & López-Martínez, 1984; Peters, 2000a) (Tab. 8).

The new specimens described here confirm that the architecture of the pelvis and hindlimb in *Tanystropheus* is very similar to that of the presumed terrestrial taxa *Macrocnemus* (Rieppel, 1989) and *Langobardisaurus* (Renesto, 1994; Renesto *et al.*, 2002). However, major differences, are observed in the pes.

Table 8 – Length ratios between different elements of the forelimb and the hindlimb in the protorosaurs *Tanystropheus longobardicus*, *Tanytrachelos ahynis*, *Langobardisaurus tonelloi*, *Cosesaurus aviceps* and *Macrocnemus bassanii*. The length of the manus and pes is considered to be the length of the longest unit "metacarpal/metatarsal+phalanges".
1) *Tanystropheus longobardicus*, MSNM BES SC 265.
2) *Tanystropheus longobardicus*, MSNM BES SC 1018.
3) *Tanytrachelos ahynis*, YPM 7622, Olsen, 1979.
4) *Langobardisaurus tonelloi*, MFSN 1921, Muscio G., 1997 and pers. comm., 2006.
5) *Cosesaurus aviceps*, MGB-V1, Sanz & López-Martínez, 1984.
6) *Macrocnemus bassanii*, MSNM BES SC 111.

Length ratios	**1**	**2**	**3**	**4**	**5**	**6**
humerus/femur	0.7	-	0.9	0.7	0.6	0.8
humerus/radius	1.4	1.5	-	1.3	-	1.1
humerus/manus	-	2.0	-	-	-	1.8
radius/manus	-	1.4	-	-	-	1.6
femur/tibia	1.2	-	1.8	1.1	1.2	0.9
femur/pes	1.1	-	1.2	1.2	-	0.9
tibia/pes	1.0	0.9	0.7	1.1	-	1.0

The pelvic girdle of *Tanystropheus* is small compared to the size of the hindlimb and is very similar in shape and proportions (relative to the hindlimb) to that of *Macrocnemus* (Rieppel, 1989: fig. 4 B). *Langobardisaurus* (Renesto *et al.*, 2002: fig. 3 A) has a distinct, posteriorly projecting process on the ischium, which is absent in *Macrocnemus* and *Tanystropheus*. Contra Renesto (2005) and Rieppel (1989), *Tanystropheus* does have a preacetabular process (Fig. 25) similar to that of *Langobardisaurus* (Renesto *et al.*, 2002), yet it remains smaller than that of *Macrocnemus*. In the latter, the preacetabular process is robust and turned outward in an unusual manner (Rieppel, 1989: 384, fig. 6).

The femur of *Tanystropheus* (Figs. 1, 8, Pls. I-IV) is long and slender, and only slightly expanded proximally. There is no medial deflection of its proximal articular head (Fig. 26). This feature indicates a sprawling gait. The distal end of the femur displays rounded condyles (Fig. 29). The tibia and fibula are of sub-equal length (Figs. 1, 8, Pls. I-IV, Tab. 5); a spatium interosseum is present. The tibia has slightly and equally expanded ends, the slender fibula has no expanded ends. The proximal articular surfaces of the tibia and the fibula are flat or slightly convex. The knee joint (Fig. 29) is apparently hinge-like and fully functional.

The tarsus of *Tanystropheus* differs from that of *Macrocnemus* and *Langobardisaurus* (Fig. 66) in having only four ossified elements (Fig. 61) and a distinct mesotarsal joint between the proximal and distal elements (Fig. 64). With the exception of PIMUZ T 2480 (Fig. 63), on which Wild based the reconstruction of the pes (Wild, 1974: fig. 77), the elements of the tarsus in the *Tanystropheus* material in the PIMUZ Collections are invariably displaced (Wild, 1974: figs. 74-76). This might suggest a looser articulation than that observed in the very compact tarsus of *Macrocnemus* and *Langobardisaurus*. A dislocation of the crus and tarsal ossifications seems to be the general rule. It is indicative of a looser crurotarsal joint in *Tanystropheus*, than in *Macrocnemus* (Rieppel, 1989: fig. 8; Fig. 66 D in this paper) and *Langobardisaurus* (Fig. 66 A-C), although overall the ankle joint is quite similar in all three taxa. In *Langobardisaurus* the tibia and the fibula fit loosely into concavities formed by the proximal borders of the astragalus, calcaneum and centrale (Renesto *et al.*, 2002). In *Macrocnemus* (Rieppel, 1989), the fibula is received in an embayment formed by the astragalus and calcaneum. The tibia articulates with the astragalus, bearing a distinct articular facet on its medial side. This facet forms the proximal part of an embayment completed by the centrale and distal tarsal one, within which the tibia is accomodated during the propulsive phase of the stride (Rieppel, 1989). In *Tanystropheus,* the articular facet formed by the astragalus and calcaneum for the fibula is similar to that described in *Macrocnemus*. There is no identifiable facet for the tibia on the astragalus. However, in MSNM BES SC 265 (Fig. 65) the tibia, even though it is displaced medially, still contacts the astragalus. The presence of a cartilaginous centrale in the tarsus of *Tanystropheus*, as discussed above, is consistent with the configuration of the ankle joint in other protorosaurs, in which a contact of the tibia with the centrale is observed (Benton & Allen, 1997; Dilkes, 1998).

Dislocation of the tarsus and metatarsus is commonly observed in the fossil material of *Tanystropheus*. By contrast, the metatarsals are in most cases preserved in association, with their proximal ends overlapping. As in other protorosaurs, this suggests that the metatarsals formed a functional unit. Metatarsal V has an outer process and a lateral tubercle similar to the presumed terrestrial *Macrocnemus* (Rieppel, 1989) and *Langobardisaurus* (Renesto *et al.*, 2002). The presence in the foot of *Tanystropheus* of a metatarsal-like first phalanx on digit five is a character shared with other protorosaurs, in particular *Tanytrachelos*, *Langobardisaurus* and *Cosesaurus*. In *Tanystropheus*, however, the articulated phalanx exceeds the length of metatarsals I-IV, while in *Tanytrachelos*, *Langobardisaurus* and *Cosesaurus* it is shorter than the longest metatarsal (metatarsal III in *Tanytrachelos*, Olsen, 1979: fig. 4 A; metatarsal IV in *Langobardisaurus*, Renesto *et al.*, 2002: fig. 5, and *Cosesaurus*, Ellenberger, 1977: fig. 12). The phalangeal formula of the pes in *Tanystropheus* (2,3,4,5,4) is the same as in *Tanytrachelos*, *Langobardisaurus* and *Macrocnemus* (Tab. 9).

Comparing the limbs of *Tanystropheus* with those of other protorosaurs, and, in particular, those of the recently discovered Chinese protorosaur *Dinocephalosaurus* (Li, 2003; Li *et al.*, 2004), Renesto (2005) concluded that the morphology of the limbs of *Tanystropheus* rules out any kind of aquatic locomotion. He also emphasized that none of the authors who had proposed a fully aquatic mode of life for *Tanystropheus* outlined which mode of propulsion was adopted by this reptile. In fact, Tschanz (1985; 1986) did suggest that *Tanystropheus*

Table 9 – Comparison of the phalangeal formulae of the manus and pes in the protorosaurs *Tanystropheus longobardicus*, *Tanytrachelos ahynis*, *Langobardisaurus*, *Cosesaurus aviceps,* and *Macrocnemus bassanii*.

Phalangeal formula	Manus	Pes
Tanystropheus longobardicus	2,3,4,4,3	2,3,4,5,4
Tanytrachelos aynis Fraser N. C., pers. comm., 2007	2,3,4,4,3	2,3,4,5,4
Langobardisaurus Renesto *et al.*, 2002	2,3,4,5,3	2,3,4,5,4
Cosesaurus aviceps Ellenberger, 1997	1,2,3,3,1?	2,3,4,5,3
Macrocnemus bassanii Rieppel, 1989	2,3,4,5,3	2,3,4,5,4

was an axial-subundulational swimmer (*sensu* Braun & Reif, 1982; 1985), in which locomotion resulted from undulatory movements of the trunk and tail, additionally supported by paddling of the hindlimbs. However, Tschanz did not discuss in detail the morphology of the hindlimb in *Tanystropheus* and did not explain how this paddling was possible.

Assuming an aquatic mode of life for *Tanystropheus*, it is still most likely that it returned to land for reproduction, in which case it must have been capable of moving on land in some way. However, nobody has ever tried to explain in detail how this reptile walked. Although a detailed analysis of locomotion is beyond the scope of this paper, some points are raised below.

The absence of articular cartilages in the fossil material limits a complete understanding of the full range of movements possible at any joint. The shape of the femur apparently indicates a sprawling gait for *Tanystropheus*. Rieppel (1989) pointed out that with a sprawling gait there is a requirement for some rotation of the lower limb relative to the femur, and that in extant squamates this rotation does not take place within the knee joint, as demonstrated by Rewcastle (1980) but in the mesotarsal joint. In *Macrocnemus*, in the absence of such a joint, as well as of an archosauromorph-like articulation between the astragalus and calcaneum, Rieppel (1989) stated that the rotation took place between the crus and the proximal tarsal ossifications (p. 74, Fig. 67). As a result of this movement, the distal metatarsal heads would be aligned at right angles to the body axis, thereby distributing the body weight during the propulsive phase of the stride. Renesto *et al.* (2002) assumed a similar rotation movement in *Langobardisaurus*. In the latter, however, the presence of a larger and more transversally elongate centrale, the lack of distal tarsal one, and the presence of a second axis of rotation between the centrale-astragalus-calcaneum and the distal tarsals-metatarsals, would have resulted in a more anterior orientation of the pes than in *Macrocnemus* (Renesto *et al.*, 2002).

Ongoing research indicates a digitigrade stance in the pes of many protorosaurs, including *Tanytrachelos* (Peters, 2000b: figs. 9 B, 15 A), *Cosesaurus* (Peters, 2000b: fig. 16), *Macrocnemus* (Avanzini & Renesto, 2002) and *Langobardisaurus* (Renesto *et al.*, 2002), and to a bipedal posture, during rapid locomotion - as previously stated by Rieppel (1989) for *Macrocnemus* - or even while standing and walking.

For *Tanystropheus*, a digitigrade stance in the pes is the only plausible configuration while walking as well. Any analysis of terrestrial locomotion in *Tanystropheus* must take into account the metatarsal-like proportions of the first phalanx of digit five during pedal plantarflexion (*sensu* Brinkman, 1980: 278). As mentioned above, the length of this phalanx, when articulated with metatarsal V, exceeds that of the longest (III) metatarsal. Intuitively, it is clear that only the elements of the pes distal to the distal end of the metatarsal-like phalanx could contact the ground. Furthermore, the metatarsus of *Tanystropheus* is asymmetrical, although not in the same manner as *Macrocnemus*, *Langobardisaurus* and *Cosesaurus*. In the latter taxa there is a regular increase in length from metatarsal I through metatarsal IV. In *Tanystropheus*, the longest metatarsal is metatarsal III, followed by metatarsal IV, metatarsal II and metatarsal I. *Tanytrachelos* (Olsen, 1979: fig. 4) apparently has a similar metatarsal configuration. Again, however, the length of the articulated metatarsal-like phalanx of digit five in *Tanytrachelos* does not exceed the length of the metatarsals. Analysing the hinge lines (Peters, 2000b) and comparing the pes of *Tanytrachelos* with the *Gwynnedichnium* trackmaker, Peters (2000b: figs. 9 B, 15 A) suggested that the pes of *Tanytrachelos* could adopt both a plantigrade and digitigrade configuration. Peters also drew hinge lines in the pes of *Tanystropheus*, as reconstructed by Wild, briefly discussing the pattern obtained (Peters, 2000b: 30, fig. 15 B). Nevertheless, he was unable to come to a definitive conclusion about the possible configuration for the pes in this protorosaur. A preliminary examination of the hinge lines on the superbly preserved left pes of MSNM BES SC 1018 shows a slightly different pattern than that figured by Peters in the plantigrade configuration. The medial and transversal set of lines are more distal (Ma, Ta and Tb in Peters' fig. 15 A were not identified in the pes of MSNM BES SC 1018), and clearly distal to the articulation of the metatarsal-like phalanx of digit five and the subsequent phalanx. The whole lateral set of lines is too tangential to have a functional meaning.

Any configuration of the pes in *Tanystropheus* requires its re-orientation to bring a set of hinge lines oriented at right angles to the direction of locomotion. While the ankle joint in *Tanystropheus* is similar to that of *Macrocnemus* and *Langobardisaurus*, in the absence of an ossified centrale, if any, in *Tanystropheus*, there is no solid

embayment constraining the dislocation of the tibia along the medio-distal margin of the tarsus. This dislocation is responsible for rotation and consequently the outward orientation of the pes. The main movement permitted at the crurotarsal joint in *Tanystropheus* was probably flexion and extension of the ankle.

In contrast to *Macrocnemus* and *Langobardisaurus*, a (poorly specialized) mesotarsal joint is present in the tarsus of *Tanystropheus*. In the reconstruction presented here (Fig. 64, p. 72), such a joint would have permitted the dorsiflexion of the unit comprising the distal tarsals and metatarsals on the unit comprising the astragalus and calcaneum. A little mutual rotation of the two units might have been possible but I doubt that the extent of this movement permitted the re-orientation of the pes required for the propulsive phase of the stride.

On the other hand, the prevalent movement of flexion-extension at the ankle and at the mesotarsal joint in *Tanystropheus*, together with the unossified medial part of the tarsus and the loose joints between the tarsal elements - and also between the tarsus and the crus - are consistent with a paddling motion. The overall flexibility of the pes was apparently more important than the mobility at each joint.

Skeletal correlates for an efficient pedal plantarflexion (Rieppel, 1989) include a well differentiated "hooked" (p. 73) metatarsal V, with an outer process and distinct lateral and medial tubercles, and elongate metatarsals I-IV forming a single functional unit. The occurrence of some of these features in *Tanystropheus* might be interpreted as plesiomorphic and inherited from a common ancestry within the terrestrial protorosaurs.

Tanystropheus mode of life: on what side of the shoreline?

The skeletal anatomy of *Tanystropheus* is unique and there is no equivalent in either extant or extinct animals. The recently described Chinese protorosaur *Dinocephalosaurus* (Li, 2003; Li *et al.*, 2004) has an overall form closely recalling *Tanystropheus*. However, in *Dinocephalosaurus* the proportions of the limbs, with shortened epipodials, the poorly ossified carpus and tarsus, the rounded astragalus and calcaneum, and the poor differentiation of metatarsal V, unequivocally indicate the adaptation to an aquatic mode of life.

Critical issues in the interpretation of the mode of life for *Tanystropheus* include the general proportions and shape of the body, skeletal anatomy, mobility of the long neck and static problems related to it, locomotion (see also the preceding section), and feeding.

Tanystropheus does not have a compact and streamlined body (Taylor, 1989). The trunk is very short compared with the extremely long neck and the tail. The latter is neither deep and/or laterally compressed. The gracile limbs are not paddle-shaped, and neither shortened nor broadened. The pes is very long relative to the crus and the femur, but similar proportions are observed in the related, presumed terrestrial taxa *Langobardisaurus* and *Macrocnemus* (Tab. 8). Except for the disproportionately elongate neck, the overall form of the skeleton of *Tanystropheus* is not strikingly different from that of the latter taxa.

Nevertheless, Rieppel (1989) underlined many skeletal correlates indicative of terrestrial habits for *Macrocnemus* which are absent in *Tanystropheus*, and emphasized that the overall degree of ossification is less in adult *Tanystropheus* than in *Macrocnemus*. This might well indicate that *Tanystropheus* was an aquatic animal throughout its life. In fact, the mild degree of skeletal paedomorphosis observed in *Tanystropheus* might have important functional effects. As discussed in the preceding section, the morphology of the pes in *Tanystropheus* does not suggest a marked adaptation to an aquatic mode of life, yet it renders it difficult to imagine efficient terrestrial locomotion. Moreover, the minimal degree of ossification of the carpus and the reduced size of the forelimb suggest that the forelimb was not a major contribution to any kind of locomotion (Renesto, 2005).

Renesto (2005) emphasized that the extremely long, yet scarcely flexible, neck of *Tanystropheus* seems unsuitable in any environment, and summarized an overall view of previous studies (Renesto, 2005: 387, fig. 10). According to Peyer (1931), Wild (1974) and Kummer (1975) the neck of *Tanystropheus* was rather mobile and held horizontally or considerably raised.

The axial locomotory system in *Tanystropheus* was more recently interpreted by Tschanz (1985; 1986) drawing a comparison with extant reptiles (*Iguana* and *Varanus*), and the neck was concluded to have been almost inflexible. Tschanz compared the neck of *Tanystropheus* to an architectural construction in which the interspinal ligaments and the intervertebral muscles represent a tension boom between two neighbouring vertebrae, while the bundles of cervical ribs represent a strut. The final result would be a neck incapable of dorsal flexion. Tschanz maintained that the neck could only be held horizontally and not raised above the level of the shoulder. According to Tschanz, this configuration is strongly indicative of a fully aquatic mode of life for *Tanystropheus*. Buoyancy would have supported the long neck in the water and would have reduced the hydrostatic stress on the cardiovascular system.

By contrast, according to the most recent interpretation by Renesto (2005), there would be evidence indicating that the neck was more flexible and mobile than suggested by Tschanz. The shafts of the cervical ribs, running in tight bundles ventral to the vertebral column, would have at least partially constrained the dorsoventral flexion of the neck but there would have been some limited flexibility, so that the neck was not completely rigid. As a result of the hollow vertebral centra, it was very light and, even in the absence of a strong epaxial musculature, it could have been supported on land, held in an inclined posture. Drawing a comparison with the long-necked azdarchid pterosaurs, Renesto (2005) conjectured that *Tanystropheus* likewise possessed a muscle/ligament system allowing the neck to be raised above the horizontal plane.

According to Renesto (2005), the form of the 12th cervical vertebra in *Tanystropheus* would account for the inclined posture of the neck. Its forward-slanting posterior surface, when in juxtaposition with the flat anterior surface of the first dorsal vertebra, would produce an angle at the base of the neck. However, the presence of an asymmetrical intervertebral disc (Tschanz, 1986: 65) or a slightly dorsally curved vertebral column in the trunk

region might well result in a horizontally stretched neck, even in the presence of the forward-slanting posterior surface of the 12th cervical vertebra.

Concerning the static problems related to the presence of a long neck in the terrestrial environment, Renesto (2005) emphasized that the whole anterior portion of the body of *Tanystropheus* would have been lighter than the posterior one, and speculated that a large muscular mass at the base of the tail shifted the centre of mass posteriorly, thus stabilizing the body. He cited as evidence for the presence of this muscular mass the massive patches of black matter and a large number of small spherules comprising tiny calcium carbonate crystals at the base of the tail. It is not clear, however, whether this type of preservation is related to peculiar taphonomical conditions characterizing the levels of the Lower Meride Limestone from which the specimen - collected from an isolated block - is alleged to have come (Renesto, 2005: 378), and whether it is observed in other fossil vertebrates from the same levels. This would support Renesto's interpretation. I concur with Renesto that the presence of the long pleurapophyses of the proximal caudal vertebrae is related to muscular insertions. At the same time, many extant reptiles, including lizards, have caudal lipid stores. In the viviparous skink *Niveoscincus metallicus* caudal fat bodies comprise the majority (55-78%) of the fat reserves, and the 90-95% of caudal fat occurs within the proximal third of the tail (Chapple & Swain, 2002). Finally, stabilization of the body due to the weight of a posterior, large muscular mass might also be equally advantageous in an aquatic animal.

Analysing the patterns of aquatic locomotion within the Sauropterygia and discussing the probable steps in the origin of aquatic locomotion among reptiles, Carroll & Gaskill (1985) pointed out that in the early stages of aquatic adaptation propulsion in water is mainly achieved through lateral undulations of the axial skeleton. In the majority of secondarily aquatic reptiles, use of limbs is disadvantageous in water because of the constraints imposed by the morphology and stereotyped pattern of movement inherited from close terrestrial ancestors. Therefore, the emphasis put on the forelimbs for propulsion that is observed in nothosaurs and plesiosaurs can be interpreted as secondary, and subsequent to a progressive reduction of the forelimbs to limit drag in the early stages of aquatic adaptation. Extant crocodiles and the marine iguana also swim with lateral undulations of the trunk and tail, keeping the forelimbs close to the body and mostly trailing the hindlimbs, which are occasionally thrust backwards in a paddling motion (Carroll & Gaskill, 1985). On the other hand, Braun & Reif (1985) stated that discontinous propulsion, because of its low efficiency at medium to high Reynolds-numbers, plays practically no role in fish. At the same time, discontinuous propulsion such as paddling occurs in semi-aquatic tetrapods which can also walk, fly, jump, and even climb. Usually, adaptation to rowing and paddling requires minor anatomical changes of the terrestrial locomotory apparatus (Braun & Reif, 1985). In the light of the discussion above, Tschanz's (1985; 1986) interpretation of *Tanystropheus* as an axial-subundulational swimmer (*sensu* Braun & Reif, 1982; 1985), which might have also used the hindlimbs as paddles, seems consistent.

Other long-necked reptiles, such as the plesiosauroid plesiosaurs, have been interpreted as relatively slow swimmers living in coastal environments. While they had evolved efficient propulsive mechanisms, plesiosaurs, in particular long-necked plesiosauroids, have a poor hydrodynamic profile (Massare, 1988): the long neck, increases drag. In the diagram of "fineness ratios" published by Massare (1988: fig. 2), some plesiosauroids do not fall into the category representing body shapes which minimize the total drag and which are optimal for fast, continuous swimmers. According to Massare, many of the plesiosauroids had a slower cruising swimming speed for a given size than fusiform-shaped marine reptiles such as ichthyosaurs and pliosauroids. Forrest R. (pers. comm., 2007) emphasizes that, from a hydrodynamic point of view, a stiff neck is essential and there is a growing consensus that the neck flexibility in some plesiosauroids was akin to a stiff fishing rod (see also Ford, 2002). Interpreting *Tanystropheus* as an axial-subundulational swimmer, Tschanz (1985; 1986) underlined that in this kind of swimmer the anterior part of the body must be rigid, and that the stiffened part of the body in *Tanystropheus* is represented by the elongate neck.

The new *Tanystropheus* specimens confirm that the articular surfaces of the pre- and postzygapophyses of the dorsal vertebrae posterior to the second-third and of the caudal vertebrae are oriented more or less horizontally, and therefore permit lateral movements. While Tschanz (1985) stated that the caudal haemapophyses are moderately elongate, I concur with Renesto (2005) in saying that, on the basis of skeletal evidence, the tail in *Tanystropheus* is not powerful, enlarged and laterally flattened as it would be expected in a tail-propelled tetrapod. However, albeit highly speculative, the hypothesis that the shape of the tail in the living animal was different from that indicated by the skeletal morphology cannot be excluded. Thus, for istance, it is possible that fins composed of soft tissue were present in the living animal. According to Renesto (2005), the elongate pleurapophyses of the proximal caudal vertebrae would have hindered lateral undulation of the tail. However, the pleurapophyses in specimen MSNM BES SC 265 (Fig. 6) are not too long to completely preclude lateral movement, and, if the length of the tail is taken into account, little lateral movements at any vertebral joint might well have produced an appreciable lateral movement of the tail as a whole.

In the light of the discussion above, I regard *Tanystropheus* as an aquatic protorosaur with close terrestrial ancestors, living in shallow waters (maximum a few ten meters deep, Rhöl *et al.*, 2001) and in all probability returning to land for reproduction. I concur with Tschanz (1985; 1986) that *Tanystropheus* was a slow, not highly specialized swimmer, relying on lateral undulations of the trunk and tail for aquatic propulsion, perhaps enhanced by paddling with the hindlimbs.

A critical, still unclear issue in the interpretation of the mode of life for *Tanystropheus* is feeding, in particular method of capture and processing prey. Stomach contents were reported by Wild (1974: 51, 142) in some large-sized specimens of *Tanystropheus*. They consist of fish and hooklets from cephalopods' arms. This suggests that *Tanystropheus* had the capability to seize elusive prey. However, it is difficult to imagine how it could catch such preys both in water and from the shoreline, especially if the neck was stiff.

As discussed by Massare (1988), the swimming capabilities of Mesozoic marine reptiles have implications for the mode of predation. Plesiosauroid plesiosaurs provide a model of feeding strategies that might be adopted by an aquatic, long-necked animal. Because of their slower continuous swimming speeds, plesiosauroids had the option for one of three strategies: pursue slow prey, eat sessile prey or use an ambush technique to capture prey (Massare, 1988). According to Massare, the possibility of an ambush mode of attack is more speculative for the plesiosauroids than for the crocodiles and mosasaurs. However, very long-necked plesiosauroids might have been ambush predators, the prey being caught before the large body was even detected in dark, murky water (Massare, 1988). There is also evidence that the four flipper "gait" of plesiosaurs, while not especially efficient for normal locomotion, was very well suited for rapid acceleration required in the ambush method of predation (Long Jr. *et al.*, 2006). McHenry *et al.* (2005) recently found stomach contents dominated by benthic invertebrates in two Australian elasmosaurid specimens, suggesting that even structures as specialized as the elasmosaurid neck are not necessarily indicative of very specialized niches. This is confirmed by the wide range of tooth forms found in the long-necked plesiosaurs (Forrest R., pers. comm., 2007).

Contra Wild (1974: 142), it seems very unlikely that an aquatic *Tanystropheus* was a fast swimmer pursuing slower prey. An ambush method of capturing prey, requiring fast starts and rapid acceleration of the body, i.e. short bursts of swimming, also seems improbable for *Tanystropheus* (but see Ford, 2002).

An alternative ambush method of capturing prey was hypothesized by Peters (2005) for the recently described, aquatic protorosaur *Dinocephalosaurus*. According to Peters, this animal was a sit-and-wait predator, hiding in bottom silt and snatching passing fish from below. Peters considered the same model applicable to *Tanystropheus* as well. Li *et al.* (2004) argued that extending the head vertically would have been impossible for *Dinocephalosaurus* because the hydrostatic pressure would have prevented lung inflation. Peters (2005) suggested that this problem could have been overcome by gulping a small bubble of air and carrying it to the bottom in the throat sac before passing it to the lungs under equalized pressure. Contra Peters, LaBarbera & Rieppel (2005) maintained that *Dinocephalosaurus* was unlikely to have been a benthic ambush predator, because its orbits are not facing dorsally and the morphology of the cervical vertebrae indicate that dorsiflexion of the neck was impossible. Moreover, such motion would generate high drag forces on the neck that would tend to drag the body of the animal in the direction opposite to the motion of the head.

Li *et al.* (2004) maintained that a form of suction feeding was a possible strategy for *Dinocephalosaurus*. Moderate lateral flexion of the neck, followed by rapid straightening and splaying outward of the ribs, would produce an increase in the esophageal volume, that in turn would create suction. This model was questioned by Peters (2005) and Demes & Krause (2005) who denied the possibility of an expansion of the esophagous as suggested by Li *et al.* (2004). They also argued that the feeding mechanism invoked by the latter authors would require physiologic adaptations for removal of salt from the swallowed water and/or some mechanism of secondary water expulsion. However, LaBarbera & Rieppel (2005) objected to the arguments of Peters (2005) and Demes & Krause (2005), noting that reptilian physiology automatically implies the presence of some form of salt gland. Interestingly, fossil evidence of salt glands was recently reported by Fernández & Gasparini (2000) for the marine metrorhynchid crocodiliform *Geosaurus*. LaBarbera & Rieppel also suggested that excess water might have been expelled through the orifices between the fang-like grasping teeth of *Dinocephalosaurus*.

Taylor (1989) emphasized that the stiffened neck of *Tanystropheus* seems inappropriate for an ambush strategy of prey capture, and suggested that the residual lateral flexibility of the neck might have been used for lunging the head over the prey. Tschanz also (1985; 1986) suggested that lunging the head over the prey might have been the feeding strategy of *Tanystropheus*, following a model of "kinetic inertial feeding". Given the extremely elongate neck, a minor dorsal bending in its posterior part would have permitted a sufficient retraction of the head. The energy stored by the bent cervical ribs could then be used to accelerate the head and manipulate the prey deeper into the pharynx.

Because of the stiffened neck, it is difficult to imagine *Tanystropheus* feeding on fast moving prey. Both a model of kinetic inertial feeding (*sensu* Tschanz, 1985; 1986) or suction feeding (*sensu* Li *et al.*, 2004) implies the capability of some flexion of the neck. The model suggested by Tschanz seems more plausible, given the sub-vertical orientation of the pre- postzygapophyseal articulation of the last cervical and first dorsal vertebrae. This indicates that the neck could be moved in the sagittal plane, while its lateral movement could be achieved only with a lateral movement of the trunk. Because of the poor knowledge of the cranio-cervical joint, movements of the head relative to the neck cannot be estimated.

A functional interpretation of the dentition might be relevant for our understanding of the feeding strategy adopted by *Tanystropheus*. Wild (1974: 50-51) compared the dentition in the large-sized specimens of *Tanystropheus* (his "adult" individuals) with that of marine predators such as the nothosaurs. Ford (2002) first observed that the premaxillary and anterior dentary teeth of *Tanystropheus* are interlocking and suggested that in this aspect - and in dorsally placed nares - the skull of *Tanystropheus* resembles those of fish-eating pterosaurs and sauropterygians rather than terrestrial diapsid. Indeed, the anterior conical interlocking teeth of *Tanystropheus* seem well-suited for catching prey.

The posterior tricuspid dentition of small-sized *Tanystropheus* specimens was interpreted by Wild (1974: 50) as evidence for predominant insectivorous habits. According to Wild, the tricuspid teeth were an adaptation for gripping small and fast moving prey, catched with the long, conical anterior teeth. The shagreen-like pterygoid teeth and the pointed vomerine and palatine teeth confirmed the functional interpretation of the dentition of *Tanystropheus* as a device for capturing and crushing prey.

Based on the comparison with the tricuspid dentition of the extant marine iguana, Cox (1985) alternatively conjectured an herbivorous diet for *Tanystropheus*. However, as pointed out by Taylor (1989), the absence of a very mobile neck would make it difficult for *Tanystropheus* to hunt for insects or tear algae from the rocks.

A new model for the interpretation of the tricuspid dentition in *Tanystropheus* is provided by the extant pinnipeds. These mammals tipycally display cheek teeth (or postcanines) little differentiated from one another which, particularly in the Phocidae, display a considerable variability in shape and degree of cusp development (Miyazaki, 2002a). In general, cusps are related to gripping of slippery prey. Tricuspid teeth are observed in many species. The species of the genus *Pusa* feed on fish (*P. sibirica*), fish and crustaceans (*P. caspica*), or on small fish and a wide variety of small pelagic amphipods, euphausiids, and other crustaceans (*P. hispida*) (Miyazaky, 2002b). The Harbor Seal (*Phoca vitulina*) feeds opportunistically on many kinds of fishes, shellfishes and squids (Scheffer, 1969). In some species, such as the Crabeater Seal (*Lobodon carcinophaga*), the cheek teeth have a highly modified shape with complex elongate cusps to trap and strain krill (Miyazaki, 2002a).

In a fully aquatic *Tanystropheus* the posterior tricuspid teeth might have well been an adaptation to gripping and piercing slippery, tough-skinned prey, and possibly cutting flesh. Wild (1974: 50) observed the similarity of the tricuspid teeth of *Tanystropheus* with those of the primitive flesh-eating cynodonts, but argued that they had not a shearing function. He emphasized that the tricuspid teeth in the PIMUZ specimens show horizontal rather than oblique wear facets, suggesting a tooth to tooth occlusion. However, oblique wear facets can be seen in some maxillary teeth in MSNM BES SC 265. Moreover, based on the new specimens from Besano, the tricuspid teeth of the upper jaw are positioned labial to those of the lower jaw. The upper and lower set might perhaps create a shear pattern similar to the carnassial shear of Carnivora.

Finally, some authors claimed that an interpretation of the mode of life for *Tanystropheus* based on the understanding of the function of its long neck, might be misleading (Taylor, 1989). Given the positive allometric growth of the neck in *Tanystropheus* (Tschanz, 1988; Wild, 1974), Taylor (1989) considered the great length of the neck might be an indirect consequence of the evolution of large size. In this case the large size might be an adaptation for a reason other than feeding, such as sexual competition or defence. Taylor concluded that perhaps *Tanystropheus* had a long neck simply because it was a big animal, and it survived *in spite of it* rather than because of it.

Tschanz (1988: 1002) also stated that "structures with no recognizable adaptive value may be more reasonably explained as results of allometric growth". Analysing the ontogenetic development of the neck in *T. longobardicus* and *Macrocnemus bassanii*, Tschanz observed that the positive allometric growth of the neck has different growth parameters for the two taxa. In particular, there would be evidence for a relatively longer neck and for decelerated growth of it in *Tanystropheus*, in comparison to *Macrocnemus*. According to Tschanz, this would make sense assuming the occurrence in the ancestry of *Tanystropheus*, morphologically exemplified by *M. bassanii*, of heterochronic processes, such as hypermorphosis and predisplacement, accounting for an extreme elongation of the neck with increasing body size. In the absence of decelerated growth of the neck, the accelerated body growth would have produced an elongation of the neck rendering it a functionally inappropriate or unadapted structure. Discussing the elongation of the neck in different *Tanystropheus* species, Wild (1987) apparently maintained as well that an extremely long neck was unadapted, when recognizing the specialization of the cervical vertebral region as one of several "evolutionary trends" characterizing the history of *Tanystropheus* and potentially leading to extinction.

The hypothesis that some structures characterized by unexplained but demonstrated positive allometric growth developed simply as a consequence of a positive selective pressure for a large body size was often put forward to explain "odd" morphology. As in the emblematic example of the huge antlers of the Irish Elk, peculiar anatomical traits were traditionally considered as inadaptive. Discussing the origin and function of "bizarre" structures, and, in particular, the case of the Irish Elk, Gould (1974) sharply commented on the interpretation maintaining that the enormous antlers are a passive consequence of selection for larger bodies as follows: "Curiously, this standard contention has not escaped the dead hand of the orthogenetic explanation that it bravely claimed to replace. For it assumes that the antlers were disadvantageous *per se*, and that selection preserved them only because it favored the total phenotype of larger bodies and antlers. Instead of an immutable trend, we now have an immutable correlation. Thus, the assumption of deleterious antlers was transported bodily from the orthogenetic to the allometric argument…". Gould argued that in the case of the Irish Elk, the "allometric antidote to orthogenesis" rested more upon dogmatic assumptions than "upon a firm foundation of careful and copious data", and cited evidence for a primary selective advantage for the antlers, as structures for display conditioning the female choice or establishing dominance through ritualized encounters between competing males.

Zarnik (1925) strongly claimed an adaptive meaning of the long necks of plesiosaurs: "One has to exclude the notion that these animals were the product of accidental orthogenesis which we will call hypermorphology; hypermorphological disharmony between form and function would led to their extinction (as for example, the ammonites with untwined spiral in the Cretaceous Period)". Recently, Noè (2006) emphasized that the possession of a long neck in the marine environment poses a number of functional, biomechanical, ecological and physiological problems. Nevertheless, its continued presence throughout the long evolutionary story of the plesiosaurs demonstrates that a long neck can be a successful adaptation to life in water. It's also worth noting that the tendency to hyperelongation of necks occurred in at least two, possibly three distinct evolutionary lineages in plesiosaur evolution (Forrest R., pers. comm., 2007; O'Keefe & Robin, 2001; Smith, 2003).

Finally, elongation of the neck is generally interpreted as an adaptation related to feeding strategies. In fact, "unhortodox" hypotheses on the functional meaning of neck elongation were put forward for some long-necked animals. This is the case for neck elongation in extinct sauropods (Senter, 2007) and in extant giraffe (Simmons & Scheepers, 1996), which traditionally have been thought to have evolved under the pressure of competition for food, but have alternatively been indicated as driven by sexual selection.

IMPLICATIONS FOR PHYLOGENETIC ANALYSIS

Rieppel *et al.* (2003) recently presented a synthesis of the most recent/computer supported cladistic analyses of protorosaurian interrelationships, obtained by combining the data published by Benton & Allen (1997), Jalil (1997) and Dilkes (1998). Major difficulties affecting the results of this analysis centre on a very poor knowledge of many protorosaurian taxa, as well as the description and coding of the characters included in the analysis. These problems are often related to objectivity in assessing large list of characters, within a large list of taxa, and with direct observation of all the original material.

It should probably be accepted that some characters will remain only provisionally phylogenetically informative. However, the importance of first hand systematic anatomical work of the original material cannot be over emphasized. The new specimens described here confirm this, providing new information on some poorly defined or previously undescribed characters of *Tanystropheus*. The discussion given in this paper also emphasizes how the description of some characters is (inevitably) based more on subjective interpretation of the material, rather than on strong evidence offered by the material itself.

The characters coded by Benton & Allen (1997; BA=characters by Benton & Allen), Jalil (1997; J=characters by Jalil) and Dilkes (1998; D=characters by Dilkes) are re-considered here on the basis of the descriptions and discussions presented in this paper. Contrary to Benton & Allen, Jalil did not differentiate between *T. longobardicus* and *T. meridensis* but used the genus as terminal taxon, while Dilkes considered *T. longobardicus* only. I assigne characters states for *T. meridensis* on the basis of preliminary personal observation, provisionally maintaining it as a separate species. However, the holotype, and the single known specimen, of *T. meridensis* preserves only the skull and the first six cervical vertebrae. Overlapping characters used by Benton & Allen, Jalil and Dilkes are reported in parentheses. If not mentioned, overlapping characters have been coded the same by all authors. All the characters of the different authors are provisionally considered but an important next step is to exclude characters that might be more easily affected by inaccurate scoring (see also discussion in Rieppel *et al.*, 2003). These comprise ill-defined characters, and particularly those including qualitative terms, that are therefore highly subjective. Characters that may be influenced by size, ontogenetic stage, individual variation or vagaries of preservation also should be re-evaluated. They are particularly relevant to ongoing discussions concerning the different species of *Tanystropheus* (pp. 5-6).

The coding for the following characters of the skull is confirmed or emended. Benton & Allen's coding for BA4, BA7, BA10, BA12 (J43, D35), and BA15 is confirmed both for *T. longobardicus* and *T. meridensis*. As a quadratojugal is confirmed to be absent in *Tanystropheus* (BA12, J43, D35), BA11 (J27), and J39 should be coded not applicable. Characters BA1, BA5 (J50), BA6, and BA14 (J62) are correctly coded for *T. longobardicus* and should be coded the same for *T. meridensis*. Dilkes' coding for D15, overlapping with BA5-6, is accepted. Character state 1 (nasals longer than frontals) for BA2 (J61, D18) cannot be evaluated either on the basis of the new material or for *T. meridensis*. However, PIMUZ T 2484 confirms Benton & Allen's coding for *T. longobardicus*, while character state 0 (nasals shorter than frontals) for *T. meridensis* is rejected. Nasals tapering anteromedially (J49) or with anterior process at the midline (D13) can only be confirmed on the basis of PIMUZ T 2484. Wild (1974) argued for the presence of a supratemporal, and this element is possibly present in MSNM BES SC 265 and in *T. meridensis*. Both the presence and interpretation of the supratemporal remain uncertain, however, and Benton & Allen's coding for BA13 (D31) is only provisionally accepted. Jalil's coding for J14 (D29) for *T. longobardicus* (postparietal absent) is accepted and is conceivably applicable to *T. meridensis* as well. Any coding for J3 (postparietal large or small) is consequently not applicable. Character J63, coded as unknown by Jalil, is probably better coded 0 (no teeth recurved and laterally compressed) as per Rieppel *et al.* (2003) and Dilkes (D58-59), both for *T. longobardicus* and *T. meridensis*. Jalil's coding for skull characters J2, J5, J8, J13, J15-16 (J16, D37), J18, J25 (D8 is described more in detail but this renders it not applicable to *Tanystropheus*), J28, J42, J68, and J69 is confirmed, both for *T. longobardicus* and *T. meridensis*. The coding for J17 (large exposure of the angular) is correct for *T. longobardicus*, while it is based only on Wild's (1980a) reconstruction for *T. meridensis*. However, "large" or "restricted" is subjective. Dilkes' coding for the following characters of the skull is confirmed for *T. longobardicus*: D1, D4-7, D9-10, D16-17, D19-21, D27, D30, D32-34, D36, D46, D49-50, D54-57, D60-66, D69-72, D75-76, and D127. The same character states as for *T. longobardicus* are conceivably applicable to *T. meridensis* for these characters. Many of Dilkes' characters describe the dentition and, due to the presence of specialized dentitions in protorosaurs (presence of tricuspid teeth in *Tanystropheus*; see also the dentition of *Langobardisaurus* in Renesto & Dalla Vecchia, 2000), more of these characters should be included in future analyses of protorosaurs interrelationships. I think that evidence from MSNM BES SC 1018 and *T. meridensis* is consistent with Dilkes' coding for D125 (prefrontals separate along midline). Based on the new specimens of *T. longobardicus* and on *T. meridensis* the correct character state for D73 is 0. None of the states described for D74 is applicable to *Tanystropheus*, in which the retroarticular process is formed by the angular and the prearticular without fusion of the two elements. Dilkes' coding for D45 is rejected, because the state of this character cannot be assessed in *Tanystropheus*.

Some characters of the skull should be coded differently in small- and large-sized specimens of *Tanystropheus*. Character BA3 is coded 1 (fronto-parietal suture straight) by Benton & Allen, probably based on the large-sized specimen PIMUZ T 2819 but in small-sized specimens (not clear in *T. meridensis*) the suture is interdigitating or V-shaped. Character BA16, coded 0 (pterygoid flange teeth present) for both *T. longobardicus* and *T. meridensis*, should be coded as unknown in the latter. The derived state for this character in *T. longobardicus* is only applicable to the large-sized individuals. Dilkes coded palatine and pterygoid (palatine ramus of) teeth as absent (D67-68) but this is only true for the large-sized specimens (unknown in *T. meridensis*). By contrast,

character state for D136 (crown of marginal teeth tricuspid) is applicable only to the small-sized specimens. Dilkes' coding for D25 (parietals fused with loss of suture) is only applicable to large-sized *Tanystropheus* specimens. The suture is still partly present in small-sized specimens or the two parietals are completely separated. Dilkes' coding for D26 (sagittal crest on the parietal table present) and D28 (median border of parietal drawn downwards to form ventrolateral flange) is probably based on the large PIMUZ T 2819. In the new reconstruction of the skull for the small-sized specimens the parietal table can be described as "constricted without a sagittal crest" and a ventrolateral flange is present (but see p. 52). However, preservation of the dorsal surface of the parietal is very poor in all known small-sized specimen of *Tanystropheus*.

The new specimens demonstrate that the reconstruction of the skull for small-sized specimens of *Tanystropheus* is highly speculative in some areas, and that both Wild's reconstruction and that presented in this paper cannot be considered definitive statements on skull morphology. Jalil's coding for J1 might be correct based on both reconstructions but the nature of the contact nasal-prefrontal remains hypothetic both for *T. longobardicus* and *T. meridensis*. The coding for J4 and BA9 (J54) is provisionally accepted for *T. longobardicus* but the shape of the squamosal and the nature of its contacts with neighbouring bones have been only tentatively interpreted. The same characters should be coded as unknown for *T. meridensis*. Jalil's coding for J26 (D11-12) (external naris elongate anteroposteriorly and close to the midline) is probably correct, based only on *T. meridensis*. Benton & Allen's coding for BA8 (posterior process of postorbital does not extend beyond back of lower temporal fenestra) and Dilkes' coding for D23 (ratio of lengths of anteroventral and posterodorsal processes of postorbital >1.0) are in all probability correct for *T. longobardicus*, while a postorbital was not identified in *T. meridensis*. A postorbital and parietal contact was probably absent (D22, coded unclearly) and in all probability the postfrontal entered into the margin of the upper temporal fenestra as stated by Dilkes (D24). The coding for some characters concerning the general shape of the skull (J38 and J64, similar to D2) and the shape of the upper temporal fenestra (D3) remains uncertain.

The coding for some characters of the skull cannot be evaluated either on the basis of the new material or for *T. meridensis* and remains based on Wild's (1974) reconstructions of *T. longobardicus*. Dilkes' coding for characters D38-44, D53, D126, D130, and D142 cannot be confirmed in the new specimens because the bones of the dermal palate, the basicranium, and the occipital region are poorly preserved. However, as Wild (1974) thought that cartilaginous tissue was interposed between the paroccipital process and suspensorium, the nature of their contact should not be regarded as "strong" (J7), and the correct character state for D52 should be 0 (paroccipital process ends freely). A stape is only tentatively identified in MSNM BES SC 1018 (Fig. 12) and adds no information (see character J6). The prootic is not preserved in any of the new specimens and very poorly preserved in the PIMUZ material (see characters J70, and D 47-48). Jalil and Dilkes coded differently the position of the occipital condyle relative to the craniomandibular joint (J66, anterior to the craniomandibular joint; D51, even with it) but as far as can be judged from Wild's (1974) reconstruction the correct coding is that of Dilkes. Although Wild (1974) stated that a septomaxilla is present in *Tanystropheus*, I agree with Dilkes' coding for D14 as unknown. Evidence for the presence of this element seems to be very poor.

The coding for the following characters of the axial skeleton is confirmed or emended. Benton & Allen's coding for BA17-19 (J56), BA20 (J40, D82), BA22 (J41), and BA25 (J57, D137) is confirmed for *T. longobardicus*. Only the coding for BA20 and BA22 can be confirmed for *T. meridensis*. Character BA19 should be coded as unknown for *T. meridensis*, as all the other characters of the axial skeleton considered by Benton & Allen, Jalil, and Dilkes. Trunk intercentra are absent in *T. longobardicus*. Consequently, the coding for BA24 is rejected, and that for J67 and D80 is confirmed. Character BA21 (ovoid spine-table on top of neural spine) is ambiguous. The shape of the neural spines of the dorsal vertebrae is discussed on pages 62 and 68. Benton & Allen's description (BA23=tall and rectangular) is applicable to the large-sized specimens of *Tanystropheus*. For the small-sized specimens this character is better captured by Dilkes (D85), where he codes the "dorsal neural spine height" as "low with height < length". Jalil's coding for characters J20, J29 (D83), J36 (D77), J37 is confirmed. Character J30 should be better described, because only the posteriormost cervical ribs have completely separated tuberculum and capitulum. In the anterior cervical ribs the tuberculum and capitulum are posteriorly confluent and these ribs are considered to be functionally olocephalous. The character "well-developed transverse processes of trunk vertebrae" (J31) needs to be re-described. The transverse processes in the new specimens from Besano are short but they might appear shorter than they really were because of compression (see p. 68). Moreover, while the "lumbar" vertebrae supposedly have long pleurapophyses, these might alternatively be considered as fused ribs or very long transverse processes (see note on p. 69). The same is true for the pleurapophyses of the proximal caudals (see Dilkes' character D89). Jalil's coding of J19 (no holocephalous dorsal ribs) is rejected. In fact, most of the dorsal ribs in *Tanystropheus* are holocephalous, and only the anteriormost three or four are dicocephalous. This character is better described and correctly coded by Dilkes (D86). Dilkes' coding for characters D78-79, D81, D87, D90, D92, D128, D131-134 is confirmed. "Proximal caudal neural spine height" (D88) cannot be assessed in the new specimens but Dilkes' coding is applicable to the vertebrae of *T. conspicuus* as described by Wild (1974).

The coding for the following characters of the appendicular skeleton is confirmed or emended (all unknown in *T. meridensis*). Benton & Allen's coding for the following characters is confirmed: BA26 (J44), BA29 (J47), BA30 (J10, J33 and J51), BA31 (J46), BA33-35, BA36 (J22, D100), BA37-39, BA40 (J59, D115), BA41 (J35, D116), BA42 (J53), BA43 (J58), BA44-45 and BA47 (for BA40 see comments in Rieppel *et al.*, 2003: 370; for BA41 and BA42 see discussion on pp. 71-72 of this paper). Benton & Allen's coding of BA32 (metacarpal three equal in length to, or longer than, fourth) is confirmed, while Jalil's coding of the same character (J55) is rejected. The presence of an entepicondylar groove or foramen on the humerus (BA27)

was reported by Wild (1974) for *T. conspicuus* but it is not confirmed for *T. longobardicus* (Wild, 1974; see also the specimen of *T.* cf. *longobardicus* described by Renesto, 2005), including the new specimens. Contra Benton & Allen, both Jalil (J32) and Dilkes (D107) coded an entepicondylar foramen absent. Character state 0 for BA28 (radius length relative to the humerus) is questionable. In the well preserved specimens described here the radius is 66-70% the length of the humerus. The desumption of the shape of metatarsal V (BA46, J12, D122) is a character still causing confusion (Rieppel *et al.*, 2003: 370), and clearer descriptions are needed. Jalil's coding is confirmed for J9 (D93), J11 (D121), J23, J24 (D114), J45, J52, and J71 (D138). An ectepicondylar foramen was never reported for *Tanystropheus*. Both Jalil (J21) and Dilkes (D108) coded it as absent. I reject Jalil's coding for J48 (ilium with reduced contribution in the acetabulum), and Dilkes' coding for D105 (relative contribution of pubic elements to acetabulum approximately equal) because the new specimens demonstrate that the element primarily contributing to the acetabulum is the ilium (Fig. 25). A concave-convex astragalo-calcaneum articulation is definitely absent in *Tanystropheus* (see discussion on p. 71): Jalil's coding for J34 is rejected, and Dilkes' coding for D113 confirmed. Dilkes' coding is confirmed for D94, D97, D99, D101-102, D104, D106, D109, D112, D119-120, D123-124, D135 and D144. Dilkes' coding for characters describing the shape of the interclavicle (D96 and D98) is based on Wild's interpretation of a single, fragmentary element (Wild, 1974: fig. 64). An interclavicle is only tentatively identified in MSNM BES SC 1018 (Fig. 20). The presence of a *processus lateralis* on the pubis (D103) established by Wild (1974) is not confirmed in the new specimens (p. 34). Presence and position of a centrale (D117-118) is correctly coded by Dilkes as unknown. The presence of a cartilaginous centrale in *Tanystropheus* remains highly conjectural (see discussion on p. 72). However, an ossified centrale contacting the tibia is present in the related taxa *Langobardisaurus* and *Macrocnemus*.

Finally, coding for BA48 (J60) (postcloacal bones) cannot be confirmed in the new specimens but the presence of postcloacal bones in *Tanystropheus* was established by Wild (1974) in the PIMUZ material.

At present, there is a general consensus on the archosauromorph, particularly Archosauria, affinities of *Tanystropheus*. The inclusion of Protorosauria (the priority of Protorosauria Huxley, 1871 over Prolacertiformes was established by Chatterjee, 1986) within the Archosauromorpha was formerly put forward by Gow (1975), and was consolidated in the 1980ies through the work of several palaeontologists, exhaustively summarized by Benton (1985) and Evans (1988). The strongest arguments against the inclusion of the Protorosauria inside the Archosauromorpha remain those of Wild (1974; 1980 a). In a preliminary paper (Nosotti, 1999), I maintained that the tiny elements observed in the elbow and the knee joints in MSNM BES SC 265 should be interpreted as secondary epiphyseal centers of ossification. This character was recognized by Benton (1985) and Evans (1988) as a lepidosaurian synapomorphy but was also described in pterodactyloid pterosaurs (Bennett, 1993), and discussed in the protorosaur *Macrocnemus* (Premru, 1991; Rieppel, 1989). Through a closer examination of these elements and taken together with the nature of the articular ends of the long bones in the new Besano specimens, I concluded that my earlier interpretation should probably be rejected.

Dilkes' (1998) cladistic analysis of protorosaurs interrelationships recently raised the possibility that Protorosauria as conventionally conceived are paraphyletic. This result was confirmed by the re-analysis of Rieppel *et al.* (2003). This latter paper should be consulted for an update on the more recent views on the relationships of *Tanystropheus* with other protorosaurian taxa. The sister group relationships of *Tanystropheus* and *Tanytrachelos* (Olsen, 1979), the two being the representatives of the Family Tanystropheidae, is, however, unanimously confirmed in all cladistic analyses that include both these taxa (Benton, 1985; Evans, 1988; Jalil, 1994; Benton & Allen, 1997; Peters, 2000a; Rieppel *et al.*, 2003). *Tanytrachelos ahynis*, from the Upper Triassic (Carnian) of the USA was interpreted by Olsen (1979) as an aquatic animal. At present, *Tanytrachelos* remains poorly described. More information on the anatomy of *Tanytrachelos* would provide the opportunity for interesting comparisons with *Tanystropheus* and perhaps offer new insights into the supposed aquatic radiation of the (terrestrial) protorosaurs represented by the Tanystropheidae.

CONCLUSIONS

1) New material from the Middle Triassic of Besano adds considerable detail to the knowledge of the anatomy of *Tanystropheus longobardicus*. Re-interpretations of the anatomy presented in this paper are only applicable to small-sized representatives of *T. longobardicus* and also to *T. meridensis*, that cannot be distinguished from the smallest specimens of *T. longobardicus* and is regarded here as conspecific. Three larger-sized *Tanystropheus* specimens are comprised in the new material and their morphology is described and discussed.

2) A new reconstruction of the skull is presented, developed from a clay three-dimensional model. Major novelties in the interpretation of the pre-orbital region concern the nature of the contacts between the different elements and the shape of the prefrontals. The shape, location and contacts of the nasals are reconstructed by comparison with *Tanystropheus* material in the PIMUZ Collections and remain partly speculative. The contacts between the nasals, prefrontals and frontals are only tentatively reconstructed. The fronto-parietal plate is re-interpreted: the lateral flanges of the frontal are horizontally rather than vertically oriented and the features distinguishing the dorsal and ventral surfaces of the fronto-parietal plate are described. Major difficulties were encountered in the reconstruction of the temporal region: the postorbital and the squamosal are re-described and a new tentative interpretation of their contacts with the neighbouring bones is given. The presence of a sclerotic ring in the orbit is definitely confirmed. The shape and contacts of the elements of the lower jaw are partly re-interpreted.

Fig. 67 – *Tanystropheus longobardicus*. Watercolor: Fabio Fogliazza.

3) A re-description of the axial skeleton is given, mainly based on the fully articulated MSNM BES SC 265. Differences in vertebral morphology between small- and large-sized specimens of *Tanystropheus* are assessed through comparison with three-dimensionally preserved vertebrae referred to *Tanystropheus conspicuus* and *Tanystropheus* cf. *longobardicus*.

4) The superbly preserved limbs of MSNM BES SC 1018 provide for the first time unequivocal information on the elements of the manus and pes and their articular relationships. A re-description of the tarsus based on the new specimens is given. The presence of sesamoid bones in the elbow and knee joints is reported for the first time.

5) Discussion on the morphology of the hindlimb highlights the difficulties in the interpretation of terrestrial locomotion in *Tanystropheus*. It is concluded that, although the morphology of the hindlimb is not strikingly specialized for locomotion in water, it is more consistent with an aquatic mode of life for *Tanystropheus*.

6) Based on the overall skeletal anatomy, *Tanystropheus* is regarded as an aquatic protorosaur with close terrestrial ancestors, living in shallow waters. At present, the more consistent model for aquatic locomotion in *Tanystropheus* seems to be that suggested by Tschanz (1985; 1986), who envisaged *Tanystropheus* as an axial-subundulational swimmer relying on lateral undulations of the trunk and tail for aquatic propulsion, perhaps enhanced by paddling with the hindlimbs. Major difficulties are encountered in the assessment of the method of capture and processing the prey adopted by *Tanystropheus*. The cheek dentition of extant pinnipeds is proposed as a new model for the understanding of the functional significance of the tricuspid dentition in *Tanystropheus*.

7) The notion that the extremely elongated neck of *Tanystropheus* was inadaptive is rejected, based also on comparison with plesiosauroid plesiosaurs.

8) Description and coding of the phylogenetically informative characters used in the most recent cladistic analyses are discussed in the light of the new information provided by the new material.

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REFERENCES

Arthaber G. v., 1921 – Studien über Flugsaurier auf Grund der Bearbeitung des Wiener Exemplares von *Dorygnathus Banthensis* Theod. sp. *Denkschriften der Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Klasse*, Wien, 97 (1919): 391-464.

Arthaber G. v., 1922 – Über Entwicklung, Ausbildung und Absterben der Flugsaurier. *Paläontologische Zeitschrift*, Berlin, 4: 1-47.

Avanzini M. & Renesto S., 2002 – A review of *Rhynchosauroides tirolicus* Abel, 1926 ichnospecies (Middle Triassic: Anisian-Ladinian) and some inferences on *Rhynchosauroides* trackmaker. *Rivista Italiana di Paleontologia e Stratigrafia*, Milano, 108 (1): 51-66.

Bassani F., 1886 – Sui fossili e sull'età degli schisti bituminosi triasici di Besano in Lombardia. *Atti Società Italiana di Scienze Naturali,* Milano, 29: 15-72.

Bennett S. C., 1993 – The ontogeny of *Pteranodon* and other pterosaurs. *Paleobiology*, Chicago, 19 (1): 92-106.

Benton M. J., 1985 – Classification and phylogeny of the diapsid reptiles. *Zoological Journal of the Linnean Society*, London, 84: 97-164.

Benton M. J. & Allen J. L., 1997 – *Boreopricea* from the Lower Triassic of Russia, and the relationships of the prolacertiform reptiles. *Palaeontology*, London, 40: 931-953.

Braun J. & Reif W.-E., 1982 – A new terminology of aquatic propulsion in vertebrates. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen*, Stuttgart, 164 (1-2): 162-167.

Braun J. & Reif W.-E., 1985 – A survey of aquatic locomotion in fishes and tetrapods. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen*, Stuttgart, 169 (3): 307-332.

Brinkman D., 1980 – Structural correlates of tarsal and metatarsal functioning in *Iguana* (Lacertilia; Iguanidae) and other lizards. *Canadian Journal of Zoology*, Ottawa, 58: 277-289.

Brinkman D., 1981 – The origin of the crocodiloid tarsi and the interrelationships of thecodontian archosaurs. *Breviora Museum of Comparative Zoology*, Cambridge, Massachusetts, 464: 1-23.

Broili F., 1915 – Beobachtungen an Tanystropheus conspicuus H. v. Meyer. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, Stuttgart, II: 51-62.

Carroll R. L. & Gaskill P., 1985 – The nothosaur *Pachypleurosaurus* and the origin of plesiosaurs. *Philosophical Transactions of the Royal Society*, London, B 309 (1139): 343-393.

Chapple D. G. & Swain R., 2002 – Distribution of energy reserves in a viviparous shink: does tail autotomy involve the loss of lipid stores? *Austral Ecology*, 27 (5): 565-572.

Chatterjee S., 1986 – *Malerisaurus langstoni*, a new diapsid reptile from the Triassic of Texas. *Journal of Vertebrate Paleontology,* Northbrook, 6 (4): 297-312.

Cox B., 1975 – The longest-necked lizard? *Nature*, London, 254: 654-655.

Dalla Vecchia F. M., 2000 – *Tanystropheus* (Archosauromorpha, Prolacertiformes) remains from the Triassic of the Northern Friuli (NE Italy). *Rivista Italiana di Paleontologia e Stratigrafia*, Milano, 106 (2): 135-140.

Dalla Vecchia F. M., 2006 – Resti di *Tanystropheus*, Sauropterigi e "Rauisuchi" (Reptilia) nel Triassico medio della Val Aupa (Moggio Udinese, Udine). *Gortania – Atti del Museo Friulano di Storia Naturale*, Udine, 27 (2005): 25-48.

Dalla Vecchia F. M. & Avanzini M., 2002 – New scattered remains of Triassic reptiles from northeastern Italy. *Bollettino della Società Paleontologica Italiana*, Modena, 41 (2/3): 215-235.

Demes B. & Krause D. W., 2005 – Suction feeding in a Triassic protorosaur? *Science*, Washington, 308: 1112-1113.

Dilkes D. W., 1998 – The Early Triassic rhynchosaur *Mesosuchus browni* and the interrelationships of basal archosauromorph reptiles. *Philosophical Transactions of the Royal Society*, London, B 353 (1368): 501-541.

Edmund A. G., 1969 – Dentition. In: The Biology of the Reptilia. Gans C. (ed.). *Academic Press*, London & New York, 1: 117–200.

Ellenberger P., 1977 – Quelques précisions sur l'anatomie et la place systématique trés spéciale de *Cosesaurus aviceps*. (Ladinien supérieur de Montrall, Catalogne). *Cuadernos de Geología Ibérica*, Madrid, 4: 169-188.

Evans S., 1988 – The early history and relationships of the Diapsida. In: The phylogeny and classification of the tetrapods. Benton M. J. (ed.). *Clarendon Press*, Oxford, 1: 221-260.

Fernández M. & Gasparini Z., 2000 – Salt glands in a Tithonian metriorhynchid crocodyliform and their physiological significance. *Lethaia*, Oslo, 33: 269-276.

Ford T., 2002 – A new interpretation of the skull of *Tanystropheus*. *Journal of Vertebrate Paleontology,* Northbrook, 22 (3, supplement): 53A.

Fraser N. C., Nosotti S. & Rieppel O., 2004 – A re-evaluation of two species of *Tanystropheus* (Diapsida, Protorosauria), from Monte San Giorgio, southern Alps. *Journal of Vertebrate Paleontology,* Hanover, 24 (3, supplement): 60A.

Fraser N. C. & Rieppel O., 2006 – A new protorosaur (Diapsida) from the Upper Buntsandstein of the Black Forest, Germany. *Journal of Vertebrate Paleontology,* Northbrook, 26 (4): 866-871.

Furrer H., 1995 – The Kalkschieferzone (Upper Meride Limestone; Ladinian) near Meride (Canton Ticino, Southern Switzerland) and the evolution of a Middle Triassic intraplatform basin. *Eclogae geologicae Helvetiae*, Basel, 88: 827-852.

Gauthier J., Kluge A. G. & Rowe T., 1988 – Amniote phylogeny and the importance of fossils. *Cladistics*, London, 4: 105-209.

Gould S. J., 1974 – The origin and function of "bizarre" structures: antler size and skull size in the "Irish Elk", *Megaloceros giganteus*. *Evolution,* 28: 191-220.

Gow C. E., 1975 – The morphology and relationships of *Youngina capensis* Broom and *Prolacerta broomi* Parrington. *Paleontologia Africana*, Johannesburg, 18: 89-131.

Hopson J. A., 1979 – Paleoneurology. In: Biology of the Reptilia. Gans C. (ed.). *Academic Press*, London, 9A: 39-146.

Huene F. v., 1907-1908 – Die Dinosauriers der Europäischen Triasformation, mit Berücksichtigung der aussereuropäischen Vorkommnisse. *Geologische und Palaeontologische Abhandlungen*, Supplement-Band 1. *Gustav Fischer*, Jena.

Huxley T. H., 1871 – A Manual of the Anatomy of Vertebrate Animals. *J. & A. Churchill*, London.

I.C.Z.N., 1981 – Opinion 1186. *Tanystropheus* H. v. Meyer, [1852] (Reptilia) conserved. *Bulletin of Zoological Nomenclature*, London, 38 (3): 188-190.

Jalil N.-E., 1997 – A new prolacertiform diapsid from the Triassic of North Africa and the interrelationships of the Prolacertiformes. *Journal of Vertebrate Paleontology*, Northbrook, 17 (3): 506-525.

Jurcsák T., 1975 – *Tanystropheus biharicus* n. sp. (Reptilia, Squamata) o nouă specie pentru fauna Triasică a României. *Nymphaea*, Oradea, 3: 45-52.

Jurcsák T., 1976 – Noi descoperiri de reptile fosile în Triasicul de la Aleşd. *Nymphaea*, Oradea, 4: 67-105.

Jurcsák T., 1978 – Rezultate noi în studiul saurienilor fosili de la Aleşd (Bihor, România). *Nymphaea*, Oradea, 6: 15-60.

Jurcsák T., 1982 – Occurrences nouvelles des Sauriens mèsozoïques de Roumania. *Vertebrata Hungarica*, Budapest, 21: 175-184.

Kuhn O., 1934 – Sauropterygia. In: Fossilium catalogus. I, Animalia. Quenstedt W. (ed.). *W. Junk.*, Berlin, Pars 69.

Kuhn O., 1963 – Sauria. In: Fossilium catalogus. I, Animalia. Westphal F. (ed.). *W. Junk.*, Berlin, Pars 104 (Supplementum I).

Kuhn-Schnyder E., 1960 – Hand und Fuss von *Tanystropheus longobardicus* (Bassani). *Eclogae geologicae Helvetiae,* Basel, 52 (1959) (2): 921-941.

Kuhn-Schnyder E., 1967 – Das Problem der Euryapsida. *Mitteilungen aus dem Paläontologischen Institut der Universität Zürich*, Zürich, 49: 335-348.

Kummer B., 1975 – Biomechanik fossiler und rezenter Wirbeltiere. *Natur und Museum*, Frankfurt am Main, 105: 156-167.

LaBarbera M. & Rieppel O., 2005 – Suction feeding in a Triassic protorosaur? *Science*, Washington, 308: 1112-1113.

Li Chun, 2003 – First record of Tanystropheid Reptile (Order Protorosauria) from the Middle Triassic of China. *Acta Geologica Sinica* (English Edition), Beijing, 77 (4): 419-423.

Li Chun, Rieppel O. & LaBarbera M. C., 2004 – A triassic aquatic protorosaur with an extremely long neck. *Science*, Washington, 305 (5692): 1931.

Long J. H. Jr., Schumacher J., Livingston N. & Kemp M., 2006 – Four flippers or two? Tetrapodal swimming with an aquatic robot. *Bioinspiration & Biomimetics*, Bristol, 1: 20-29.

Massare J. A., 1988 – Swimming capabilities of Mesozoic marine reptiles: implications for method of predation. *Paleobiology*, Chicago, 14 (2): 187-205.

McHenry C. R., Cook A. G. & Wroe S., 2005 – Bottom-feeding plesiosaurs. *Science*, Washington, 310 (5745): 75.

Meyer H. v., 1847-1855 – Die Saurier des Muschelkalkes: mit Rücksicht auf die Saurier aus Buntem Sandstein und Keuper. In: Zur Fauna der Vorwelt, zweite Abtheilung. *Heinrich Keller*, Frankfurt a.m.

Miyazaki N., 2002a – Teeth. In: Encyclopedia of Marine Mammals. Perrin W. F., Würsig B. & Thewissen J. G. M. (eds.). *Academic Press*, San Diego: 1227-1232.

Miyazaki N., 2002b – Ringed, Caspian, and Baikal Seals. In: Encyclopedia of Marine Mammals. Perrin W. F., Würsig B. & Thewissen J. G. M. (eds.). *Academic Press*, San Diego: 1033-1037.

Modesto S. P. & Sues H-D., 2004 – The skull of the Early Triassic archosauromorph reptile *Prolacerta broomi* and its phylogenetic significance. *Zoological Journal of the Linnean Society*, London, 140: 335-351.

Motani R., 1997 – Temporal and spatial distribution of tooth implantations in ichthyosaurs. In: Ancient Marine Reptiles. Callaway J. M. & Nicholls E. L. (eds.). *Academic Press*, 81-103.

Münster G. zu, 1834 – Vorläufige Nachricht über einige neue Reptilien im Muschelkalke von Baiern. *Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde*, Stuttgart: 521-526.

Muscio G., 1997 – Preliminary note on a specimen of Prolacertiformes (Reptilia) from the Norian (Late Triassic) of Preone (Udine, North-Eastern Italy). *Gortania - Atti del Museo Friulano di Storia Naturale*, Udine, 18 (1996): 33-40.

Noè L., 2006 – The role of the plesiosaurian long neck. A new model. *Journal of Vertebrate Paleontology,* Northbrook, 26 (3, supplement): 105A.

Nopcsa F. v., 1923 – Neubeschreibung des Trias-Pterosauriers *Tribelesodon*. *Paläontologische Zeitschrift*, Berlin, 5: 161-181.

Nosotti S., 1999 – New findings of *Tanystropheus longobardicus* (Reptilia, Prolacertiformes) in the Middle Triassic of Besano (Lombardy, Northern Italy). In: Third International Symposium on lithographic limestones. Renesto S. (ed.). *Rivista del Museo civico di Scienze Naturali "E. Caffi"*, Bergamo, 20 (supplemento): 117-120.

Oelrich T. M., 1956 – The Anatomy of the Head of *Ctenosaura pectinata* (Iguanidae). *Miscellaneous Publications, Museum of Zoology, University of Michigan*, 94: 9-122.

O'Keefe F. R. & Robin F., 2001 – A cladistic analysis and taxonomic revision of the Plesiosauria (Reptilia: Sauropterygia). *Acta Zoologica Fennica*, 213: 1-63.

Olsen P. E., 1979 – A new aquatic Eosuchian from the Newark Supergroup (Late Triassic-Early Jurassic) of North Carolina and Virginia. *Postilla*, New Haven, 176: 1-14.

Ortlam D., 1967 – Fossile Böden als Leithorizonte für die Gliederung des Höheren Buntsandsteins im nördlichen Schwarzwald und südlichen Odenwald. *Geologisches Jahrbuch*, Hannover, 84: 485-590.

Peters D., 2000a – A reexamination of four prolacertiforms with implications for pterosaur phylogenesis. *Rivista Italiana di Paleontologia e Stratigrafia*, Milano, 106 (3): 293-336.

Peters D., 2000b – Description and interpretation of interphalangeal lines in tetrapods. *Ichnos*, Chur & New York, 7 (1): 11-41.

Peters D., 2005 – Suction feeding in a Triassic protorosaur? *Science*, Washington, 308: 1112.

Peyer B., 1931 – Die Triasfauna der Tessiner Kalkalpen II. *Tanystropheus longobardicus* Bass. sp. *Abhandlungen der Schweizerischen Palaontologischen Gesellschaft*, Basel, 50: 9-110.

Premru E., 1991 – Beschreibung eines neuen Fundes von *Macrocnemus bassanii* Nopcsa (Reptilia, Squamata, Prolacertiformes) aus der Grenzbitumenzone (Anis/Ladin) von Besano, Italien. *Diplomarbeit an der Philosophischen Fakultät II der Universität Zürich*, Zürich: 1-57.

Quenstedt W., 1963 – Clavis bibliographica. In: Fossilium catalogus. I, Animalia. Westphal F. (ed.). *W. Junk.*, Berlin, Pars 102.

Renesto S., 1994 – A new prolacertiform reptile from the Late Triassic of Northern Italy. *Rivista Italiana di Paleontologia e Stratigrafia,* Milano, 100 (2): 285-306.

Renesto S., 2005 – A new specimen of *Tanystropheus* (Reptilia Protorosauria) from the middle Triassic of Switzerland and the ecology of the genus. *Rivista Italiana di Paleontologia e Stratigrafia*, Milano, 111 (3): 377-394.

Renesto S. & Avanzini M., 2002 – Skin remains in a juvenile *Macrocnemus bassanii* Nopcsa (Reptilia, Prolacertiformes) from the Middle Triassic of Northern Italy. *Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen*, Stuttgart, 224 (1): 31-48.

Renesto S. & Dalla Vecchia F. M., 2000 – The unusual dentition and feeding habits of the prolacertiform reptile *Langobardisaurus* (Late Triassic, Northern Italy). *Journal of Vertebrate Paleontology*, Northbrook, 20 (3): 622-627.

Renesto S., Dalla Vecchia F. M. & Peters D., 2002 – Morphological evidence for Bipedalism in the Late Triassic Prolacertiform Reptile *Langobardisaurus. Senckenbergiana lethaea*, Frankfurt am Main, 82 (1): 95-106.

Rewcastle S. C., 1980 – Form and function in lacertilian knee and mesotarsal joints; a contribution to the analysis of sprawling locomotion. *Journal of Zoology*, London, 191: 147-170.

Rieber H., 1973 – Cephalopoden aus der Grenzbitumenzone (Mittlere Trias) des Monte San Giorgio (Kanton Tessin, Schweiz). *Schweizerischen Paläntologischen Abhandlungen* , Basel, 93: 1-96.

Rieppel O., 1989 – The hind limb of *Macrocnemus bassanii* (Nopcsa) (Reptilia, Diapsida): development and functional anatomy. *Journal of Vertebrate Paleontology,* Northbrook, 9 (4): 373-387.

Rieppel O., 2000 – Middle Triassic marine vertebrates from the northern Gondwanan shelf. *Zentralblatt für Geologie und Paläontologie*, Stuttgart, I (9-10): 1269-1284.

Rieppel O., 2001 – A new species of *Tanystropheus* (Reptilia: Protorosauria) from the Middle Triassic of Makhtesh Ramon. Israel. *Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen*, Stuttgart, 221 (2): 271-287.

Rieppel O. & Gronowski, 1981 – The loss of the lower temporal arcade in the diapsid reptiles. *Zoological Journal of the Linnean Society*, London, 72: 203-217.

Rieppel O., Fraser N. C. & Nosotti S., 2003 – The monophyly of Protorosauria (Reptilia, Archosauromorpha): a preliminary analysis. *Atti della Società italiana di Scienze naturali e Museo civico di Storia naturale in Milano*, Milano, 144 (II): 359-382.

Robinson P. L., 1975 – The functions of the hooked fifth metatarsal in lepidosaurian reptiles. *Colloque international C.N.R.S.*, Paris, 218: 461-483.

Röhl H. J., Schmid-Röhl A., Furrer H., Frimmel A., Oschmann W. & Schwark L., 2001 – Microfacies, geochemistry and palaeoecology of the Middle Triassic Grenzbitumenzone from Monte San Giorgio (Canton Ticino, Switzerland). *Geologia Insubrica*, Lomazzo, 6 (1): 1-13.

Romer A. S., 1956 – Osteology of the Reptiles. *The University of Chicago Press*, Chicago.

Sanz J. L. & López-Martínez N., 1984 – The prolacertid lepidosaurian *Cosesaurus aviceps* Ellenberger & Villalta, a claimed "protoavian" from the Middle Triassic of Spain. *Geobios*, Lyon, 17: 747-753.

Schaeffer B., 1941 – The morphological and functional evolution of the tarsus in amphibians and reptiles. *Bulletin of the American Museum of Natural History*, New York, 78 (6): 395-472.

Scheffer V. B., 1969 – Seals, Sea Lions, and Walruses. *Stanford University Press*, Stanford.

Senter P., 2007 – Necks for sex: sexual selection as an explanation for sauropod dinosaur neck elongation. *Journal of Zoology*, London, 271 (1): 45-53.

Simmons R. E. & Scheepers L., 1996 – Winning by a neck: sexual selection in the evolution of giraffe. *The American Naturalist*, Chicago, 148 (5): 771-786.

Smith A. S., 2003 – Cladistic analysis of the Plesiosauria (Reptilia: Sauropterygia). M. Sc. unpublished Thesis, University of Bristol, Department of Earth Sciences, Faculty of Sciences.

Sulej T., 2004 – Krasiejow. The remarkable discovery of Triassc pre-dinosaurs. *Przygod Studio*, Opole.

Taylor M. A., 1989 – Neck and neck. *Nature*, London, 341 (6244): 688-689.

Tschanz K., 1985 - *Tanystropheus* - An unusual reptilian construction. In: Konstruktionsprinzipien lebender und ausgestorbener Reptilien. *Konzepte SFB 230.* Stuttgart, (4): 169-178.

Tschanz K., 1986 – Funktionelle Anatomie der Halswirbelsäule von *Tanistropheus longobardicus* (Bassani) aus der Trias (Anis/Ladin) des Monte San Giorgio (Tessin) auf der Basis vergleichend morphologischer Untersuchungen an der Halsmuskulatur rezenter Echsen. *Ph. D. Thesis Universität Zürich*, *ADAG Administration & Druck AG.*, Zürich.

Tschanz K., 1988 – Allometry and heterochronic processes in the neck-growth of the Triassic prolacertiform reptiles *Tanystropheus* and *Macrocnemus*. *Palaeontology*, London, 31: 153-179.

Underwood G., 1970 – The Eye. In: The Biology of the Reptilia. Gans C. & Parson T. S. (eds.). *Academic Press*, London & New York, 2: 1-97.

Vickers-Rich P., Rich T., Rieppel O., Thulborn R. A. & McClure H. A., 1999 – A Middle Triassic vertebrate fauna from the Jilh Formation, Saudi Arabia. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, Stuttgart, 213 (2): 201-232.

Wild R., 1974 – Die Triasfauna der Tessiner Kalkalpen XXIII. *Tanystropheus longobardicus* (Bassani) (neue Ergebnisse). *Schweizerische Paläontologische Abhandlungen*, Basel, 95 (1973): 4-162.

Wild R., 1975 – *Tanystropheus* H. v. Meyer, 1855 (Reptilia): request for conservation under the plenary powers. Z.N.(S.) 2084. *Bulletin of Zoological Nomenclature*, London, 32 (2): 124-126.

Wild R., 1976 – *Tanystropheus* H. v. Meyer, [1852] (Reptilia): revised request for conservation under the plenary powers. Z.N.(S.) 2084. *Bulletin of Zoological Nomenclature*, London, 33 (2): 124-126.

Wild R., 1980a – Die Triasfauna der Tessiner Kalkalpen XXIV. Neue Funde von *Tanystropheus* (Reptilia, Squamata). *Schweizerische Paläontologische Abhandlungen*, Basel, 102: 4-43.

Wild R., 1980b – *Tanystropheus* (Reptilia: Squamata) and its importance for stratigraphy. *Mémoires de la Société Géologique de France*, n.s., Paris, 139: 201-206.

Wild R., 1987 – An example of biological reasons for extinction: *Tanystropheus* (Reptilia, Squamata). *Mémoires de la Société Géologique de France*, n. s., Paris, 150: 37-44.

Wild R. & Oosterink H., 1984 – *Tanystropheus* (Reptilia, Squamata) aus dem Unteren Muschelkalk von Winterswijk, Holland. *Grondboor en Hamer*, Oldenzaal, 5: 142-148.

Zaher H. & Rieppel O., 1999 – Tooth implantation and replacement in squamates, with special reference to mosasaur lizard and snakes. *American Museum Novitates*, New York, 3271: 1-19.

Zarnik B., 1925 – K ethologiji plesiosaurija, sa prinosima mehanici kraljeznice u recentnih sauropsida. Zagreb.

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